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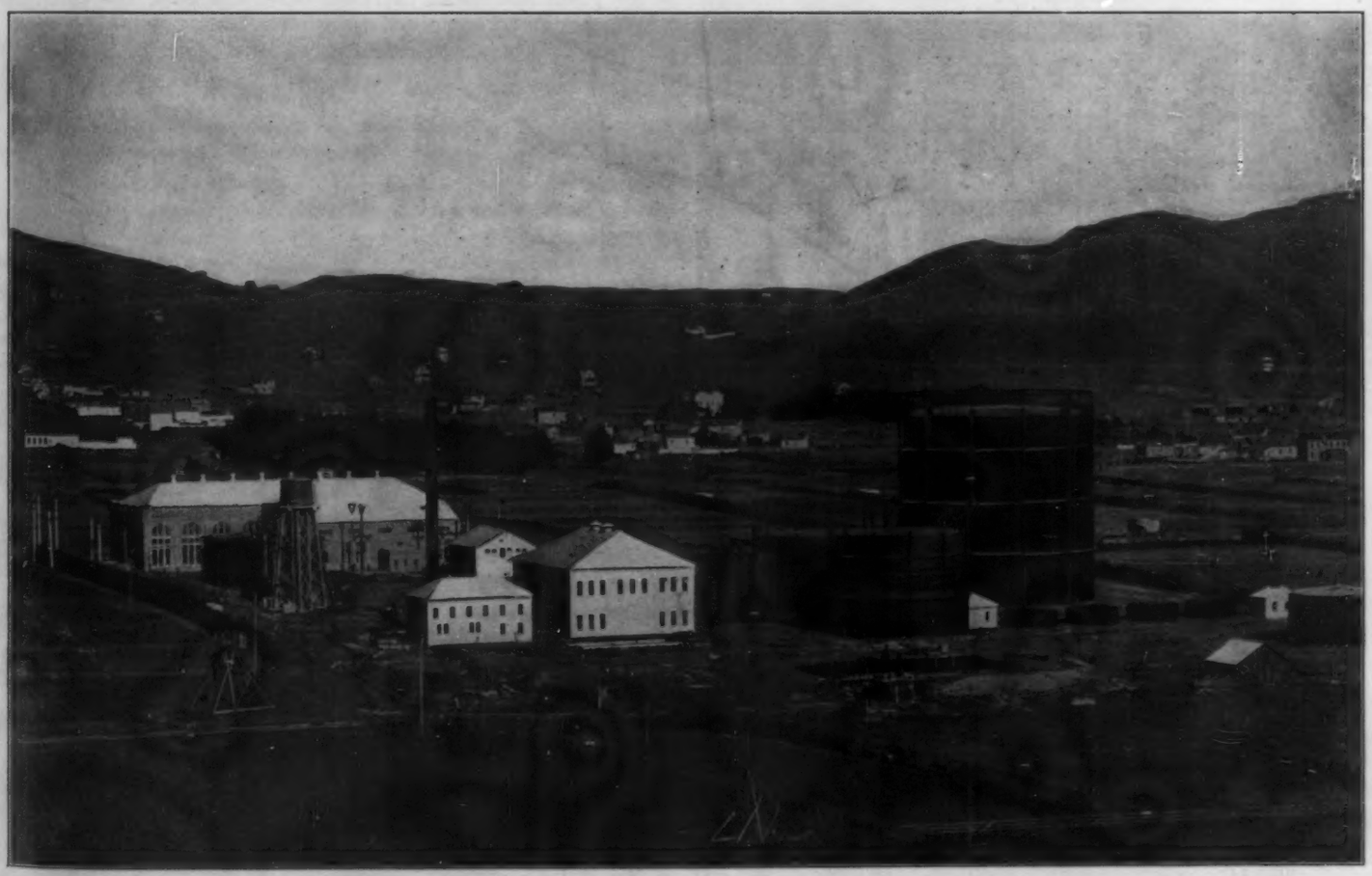
THE DEVELOPMENT OF OIL-GAS IN CALIFORNIA

BY E. C. JONES.

E.C. Jones.

The various methods of distilling oil into gas in externally heated vessels date back to the discovery of petroleum. In nearly all of these processes the oil was subjected to a comparatively low temperature in either iron or clay retorts, with unsatisfactory results attended by much trouble. Not until the introduction of generators and superheaters for water-gas making was it attempted to decompose oil in contact with highly heated surfaces of refractory material in internally heated vessels. Then the oil was looked upon as an enricher of other gases, and subservient to these dilutent gases, which took the name of water-gas. The name of oil-gas with its unctuous suggestion is apt to awaken unpleasant memories in the minds of the older generation of gas men, who experimented with the many ways of stewing oil in iron retorts. For this reason oil-gas as well as water-gas is badly named. The oil-gas of California is so much like enriched coal-gas that no chemist could identify it as having been made from oil.

The high price and scarcity of petroleum in the

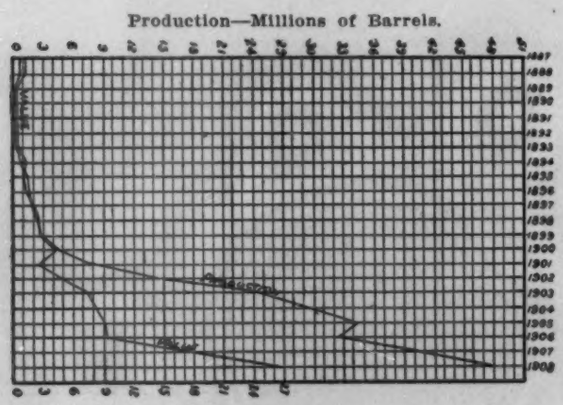


General View of Martin Station at Visitacion Valley, near San Francisco—The First Large Producer of Oil-Gas in the World.

populous and large gas-producing districts of the United States have probably deferred the invention and use of oil-gas apparatus. But the discovery of vast quantities of oil in California made it an economic necessity. The full extent of this necessity and the reasons for completely changing the method of making gas in California and the abandoning of all other generating apparatus will be better understood by referring to the following table, showing the quantity and value of petroleum produced in the State during the past twenty-one years, and to a chart, showing the relation of quantity to value.

PRODUCTION OF PETROLEUM IN CALIFORNIA.

Year	Quantity, bbls.	Value	Value a bbl.
1887	678,572	$1,357,144	$2.00
1888	690,333	1,380,666	2.00
1889	303,220	368,048	1.21
1890	307,360	384,200	1.25
1891	323,600	401,264	1.24
1892	385,049	561,333	1.45
1893	470,179	608,092	1.29
1894	783,078	1,064,521	1.35
1895	1,245,339	1,000,235	.803
1896	1,257,780	1,180,793	.90
1897	1,911,569	1,918,269	1.00
1898	2,249,088	2,376,420	1.05
1899	2,677,875	2,660,793	.99
1900	4,329,950	4,152,928	.95
1901	7,710,315	2,961,102	.38
1902	14,356,910	4,692,189	.32
1903	24,340,839	7,313,271	.30
1904	29,736,003	8,317,809	.27
1905	34,275,701	9,007,820	.26
1906	32,624,000	9,238,020	.28
1907	40,311,171	16,783,943	.41
1908	48,306,910	26,566,181	.54



Yearly Production and Value of Petroleum in California.

Until 1884 coal-gas was made in California exclusively from coals brought from Australia as ballast for English wheat-carrying ships, and coals from the State of Washington and from Vancouver Island. The finding of oil in considerable quantities encouraged the making of water-gas as an auxiliary to coal-gas, so that in 1899 there were in California one crude oil water-gas works, ten (Lowe) carburetted water-gas works, eighteen coal-gas works, five oil- and air-gas works.

This was the beginning of oil-gas making, and during the year of 1899 there were 2,677,875 barrels of petroleum produced in California. For some years after this the production of oil doubled each suceeding year, and the difficulty of finding a profitable market for this enormous increase caused a corresponding drop in the price of oil. This was the incentive for having oil displace all other crude materials for gas making.

Today there are in California fifty-six oil-gas works, and in connection with these are three plants for manufacturing water-gas from lampblack residual of oil-gas making, one small coal-gas works, and one oil and air gas plant.

The credit for discovering this new method of making gas and the invention of suitable apparatus for use in making it belongs to L. P. Lowe of San Francisco, who anticipated the eventual use of oil-gas long before the plentiful supply of cheap oil warranted its commercial use on a large scale. He constructed several small plants in different parts of California, and September 1, 1902, completed the erection of and started an oil-gas plant in the works of the California Gas and Electric Corporation in Oakland. This was the first adoption of the new process to the supply of gas to a large city, and was the basis of experiments from which the present oil-gas apparatus has developed. Improvements made it possible by September 11, 1904, to supply the entire output of Oakland.

Early Type of Apparatus.

The first type of oil-gas apparatus was constructed with the idea that extremely high heats for decomposing the oil produced the best results. It is, of course, understood that a generating apparatus consists of two or more shells filled with checker brick, and as there is no solid fuel used, there is an absence of boxes and grate bars found in the ordinary water-gas generators. The checker brick are heated by oil injected under pressure with steam in company with a blast of air for combustion. No secondary air was used in the first types of apparatus, and it was quite impossible to control the heat in different parts of the machine. The oil for heating was usually injected at the bottom of the generator under an arch or series of arches.

There is a temptation to use arches in oil-gas generators over the combustion chambers for supporting checker brick, but it was soon discovered that no arch can be constructed that will withstand the blow-pipe effect of the oil flames, and the most carefully constructed arches made of the best material obtainable lasted but a few days or weeks.

It was first supposed that burning oil in a primary shell and passing the products of combustion over checker brick in a second shell without the use of secondary air coated the checker brick in the second shell with particles of lampblack deposited from the decomposed oil, and that during the succeeding run the steam admitted with the oil for gas making was converted into carbonic oxide and hydrogen in contact with these lampblack-coated surfaces.

The high temperatures at first employed destroyed a large quantity of oil, resulting in a diminishing yield of gas at but low candlepower, and in the production of a large amount of lampblack. The yield of lampblack amounted to more than thirty pounds for each thousand cubic feet of gas made. As this lampblack was the result of decomposed hydrocarbons, the hydrogen which has been linked to this carbon remained in the gas as free hydrogen.

Following is an analysis of early oil-gas:

Composition.	Percentages.
Heavy hydrocarbons	6.2
Marsh gas	25.6
Hydrogen	62.4
Carbonic oxide	3.0
Carbonic acid gas	0.2
Oxygen	0.4
Residual nitrogen	2.2
Total	100.00

Specific gravity, .303.
Net British Thermal Units, 624 the cubic foot.

The candlepower was 18.6. This gas was made in Oakland, California, in September, 1902, and is a fair sample of the oil-gas of those days, which was produced in highly heated generators with no means of regulating the heat, without wasting it. This gas, burned through an open tip, had every appearance of coal-gas of the same candlepower, the flame being of the same size, but of apparently greater brilliancy than coal-gas. The small percentage of carbonic oxide is good evidence that little or none of the steam admitted with the oil was decomposed. This is borne out by the fact that carbonic acid gas was 0.2 per cent, and as the gas was purified by oxide of iron none of the carbonic acid was removed by purification.

The low specific gravity .303 is, of course, due to the large percentage of hydrogen, and it is undesirable for the reason that there is a greater waste in use by consumers, and the increase in street-main leakage is noticeable.

The specific gravity and hydrogen content bear so close relationship to each other that all oil-gas containing 50 per cent or more of hydrogen is of specific gravity .4 or less, and oil-gas containing less than 50 per cent of hydrogen has a specific gravity of .4 or more.

The high temperature in the generators created troubles of about the same character and disagreeable qualities as those encountered where extreme high temperatures are used in regenerative coal-gas benches.

Tar, which under other conditions would have passed over to the scrubbers and been condensed in the ordinary way, was made into pitch. The pitch mingled with the particles of lampblack and formed solid stoppages in the wash-box, so that it was no uncommon experience to make gas twenty hours one day, devoting four hours to cleaning the wash-box and down-take pipe, while on the following day twenty hours would be devoted to cleaning the wash-box, with four hours' time remaining for gas making. The lampblack recovered as a by-product was made in such large quantities that after a generous amount of it had been used for firing boilers about the works there remained a sufficient quantity to become a nuisance.

The lampblack as it is removed from the separators contains from 50 to 60 per cent of water, and it is necessary to drain off the water until the water content is reduced to about 30 per cent before the material is fit to be used as boiler fuel. The large amount of water in the lampblack prohibits the use of any of the briquetting presses that are successfully used for briquetting other dry materials, or materials containing a small amount of binder.

To add to the discomforts of making gas in this way, the wash-box was so constructed that it retained a large amount of lampblack within itself, while the lampblack separator permitted large quantities of lampblack to overflow and be wasted. This waste was not deplored so much on account of the loss in money as from the fact that the drainage from the gas works was usually emptied into a river or bay, and the State Fish Commission complained of the pollution of the water. With these discouragements and the meager amount of knowledge of the work actually being done, the construction of oil-gas apparatus in large units for the supply of gas to cities to the exclusion of all other kinds of gas seemed dangerous, and the task was unattractive.

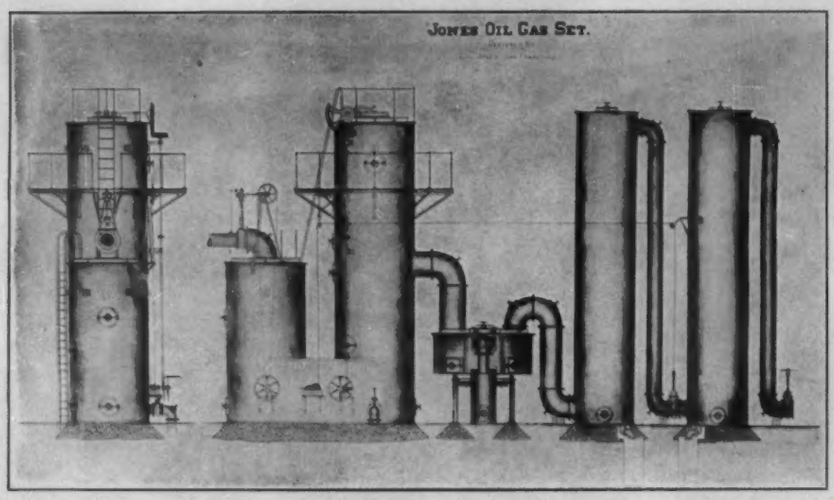
Oil-gas machinery had been constructed of all kinds and sizes with hardly two alike, and it was first necessary to design an apparatus applicable to both large and small works, and make standard every detail of it, thus accomplishing in three years the same results that have required thirty years of hard work with water-gas apparatus.

The first important improvement was the eliminating of brick arches over the combustion chamber, and the substitution of corbel work at the top of both generators in place of arches. To provide a combustion chamber without arches it was necessary to construct a pair of generators in the shape of a letter U, one leg of the U being much longer than the other. The shorter of the two shells is used as a primary generator and the air blast is admitted downward through the center of the top of this generator.

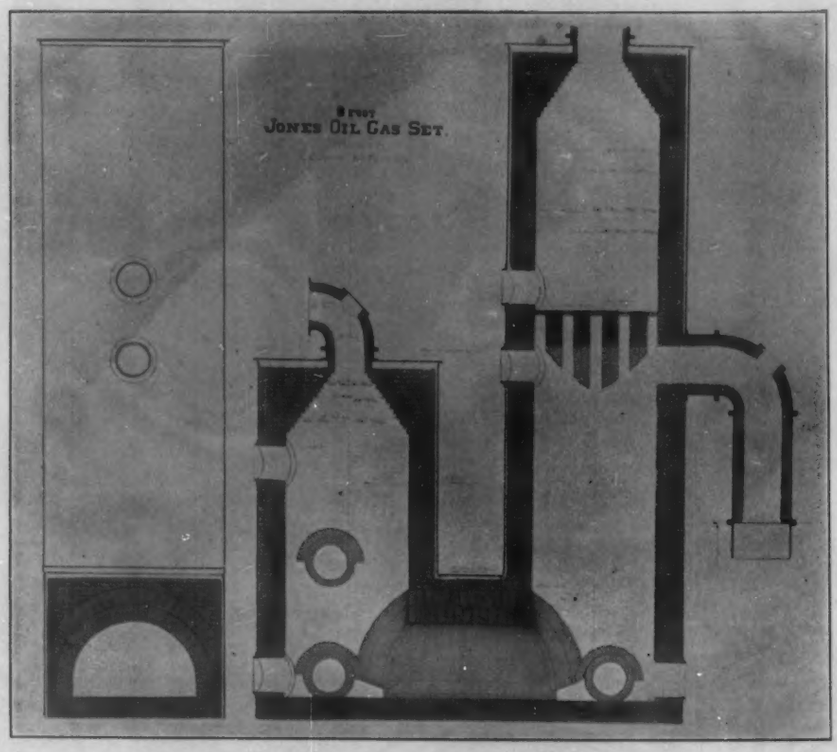
At first the oil was fed through burners pointing downward through the top of the primary in the same direction as the air. But it was found that better results were obtained by placing the oil burners in a circle around the side of the generator near the bottom of the corbel work, thus injecting the oil at several points around the circle at right angles to the direction of the air. The top of the primary thus becomes a combustion chamber, and there is no sharp impact of oil flame against any part of the brickwork. To assist a proper understanding of the apparatus, a few illustrations have been prepared; these were photographed from working drawings of a modern and satisfactory oil-gas set, as well as from apparatus now in operation.

Sequence of Operations.

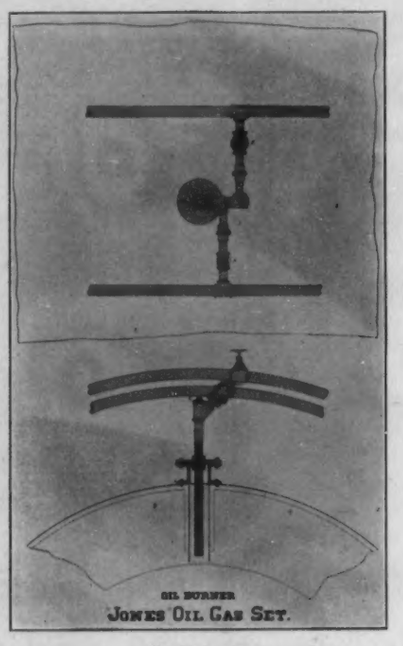
The sequence of operations in blasting and making gas, after the brickwork has been brought to a temperature that will ignite petroleum, begins with the opening of the stack valve at the top of the secondary generator and is followed by the opening of the air blast at the top of the primary generator and the admitting of oil and steam through the heating burners at the top of the primary generators. The set is entirely operated from the floor, the gas-maker and helper working in unison handling the stack-valve, the primary and secondary blast valves, and turnng on the oil and steam at the "oil table." The oil and steam for heating are admitted through a specially arranged burner shown in one of the illustrations. Separate coils of pipe encircle the generator, one being for oil, and the other for steam, that for



The Apparatus for Generating Oil-Gas.
The illustration shows the arrangement of the primary and secondary generators connecting at the bottom with a throat piece large enough not to constrict the passage for gas; shows the wash-box, which acts also as a hydraulic seal; and shows two ordinary steel scrubbers provided with wooden trays. Ample scrubbing of oil-gas is important.



Showing a Vertical Section of the Generators with Their Linings.
Note that the elbows for the admission of air and the outlet of gas are lined with fire brick to protect them from excesive heat.



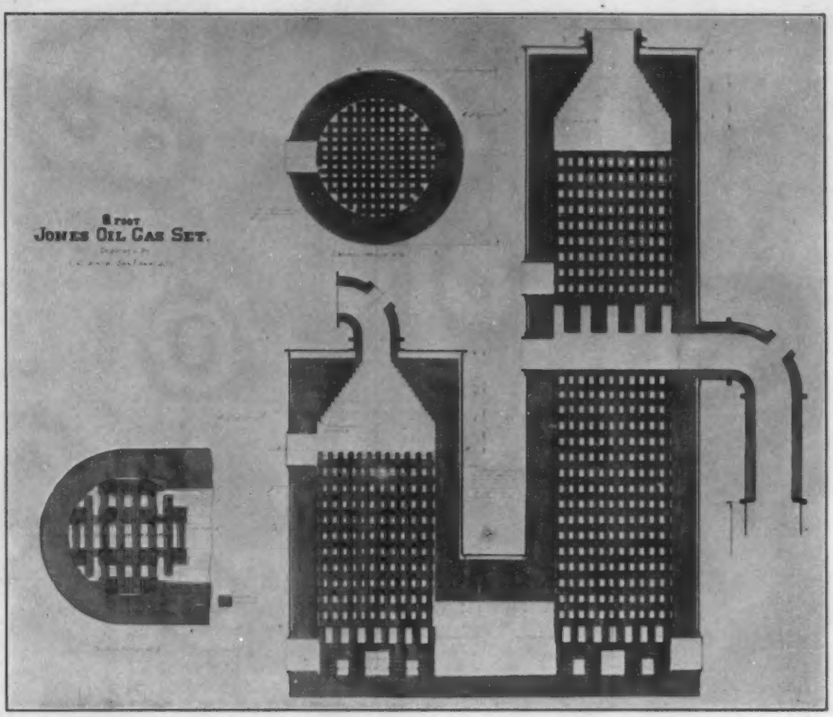
Oil Burner.

the oil always being at a lower level than the steam coil. This is a precaution to avoid a possible leakage of oil downward into the burners when the apparatus is not in use. Experience has proven that the straight pipe burner with open end gives better results in large sets than any other kind of burner. Much care, however, has been devoted to the selection of an injector, which will force the oil through the burner into the generator, using steam in the most economical manner. This injector is made of brass, carefully finished, and the oil and steam openings are nicely centered. The straight pipe burner is connected to the shell of the generator through a flange, and on the ouside end of the burner is placed a Y fitting. The injector is attached to this Y fitting, connecting it with the steam and oil pipes. This arrangement does not interfere with the workings of the injector, and has the advantage of leaving a straight way for cleaning the burner with a small rod through the plugged end, C, without disturbing the rest of the burner meahanism.

A regulation service cock is placed on the oil inlet and a standard globe valve, B, on the steam inlet to insure good regulation at the burner. These controlling valves require nice adjustment for the exact proportion of oil and steam, so that when once set the amount of oil and steam used for heating and making is controlled from the oil table.

A glance at the illustration of the oil table shows an oil table for the heating oil and one for the oil used for making gas. Gauges are provided for showing the steam pressure at the boiler, and the oil pressure at the outlet of the oil heater. In addition to this there are six nozzle gauges used in connection with each set. Three are for steam, and three for oil. These gauges are connected to the oil and steam pipe between their respective throttle valves and the machine, so that these gauges practically become steam and oil meters for the guidance of the gas-maker.

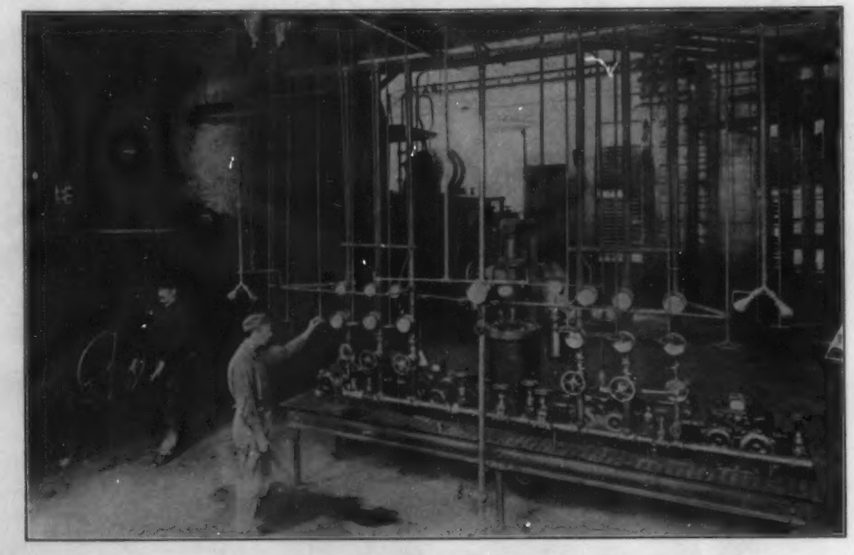
The oil table is also provided with thermometers, a jet photometer, and a test light. The oil is heated to about 150 degrees F. in a tubular oil heater of well-known design. There are nine burners for heating at the top of the primary generator. Assume that



The Arrangement of Checker Brick in the Generators.

the machine has been making gas and a blast is about to begin. The stack valve has been opened and the air is turned on at the blast valve. No oil is admitted to the machine during the first three minutes of the blast, and the steam on the burners is turned on to a sufficient pressure to keep them clean and protect them against overheating. The blast pressure inside of the primary generator is nine inches. At the end of the third minute oil is turned into the primary generator at a pressure of eight pounds inside of the machine, while the steam pressure is retained at thirty-five pounds, and the blast pressure is reduced to seven inches also within the machine.

The duration of the blast in the large machines is twelve minutes; three minutes without and nine minutes with oil.



The Operating Table Between Two 16-Feet Sets, Showing the Convenience and Simplicity of Operation.

At the end of the heat the blast valve is closed, and quick-opening valve at the outlet of the first scrubber is opened by means of a winch attached to the generator and by a wire rope running over pulleys to the valve stem. This valve is opened during runs and closed during heats, for the purpose of isolating the set from the rest of the works during the heating process and to permit the use of high blast pressure without the use of high blast pressure without breaking the seal in the wash-box, thus sending oil produced gas through the wash-box and scrubbers. As the man on the floor turns off the blast, opens the scrubber valve, and closes the stack valve, the gas-maker does not shut off the heating oil. He first turns on the oil and steam to the gas-making burners, which are separate and distinct from the heating burners. Then he shuts off the oil and steam from the heating burners so that there is no interruption in the making of gas. The heating oil serves for this purpose during the moment necessary for changing the valves. The temperature of the primary and secondary generators is observed by means of sight cocks, the gas-maker becoming very skillful in detecting changes of color in the checker brick and turning on secondary air when the outgoing stack gas has the appearance of containing combustible gas.

In this connection the personal factor represented by the skill of the gas-maker enters more largely into the equation of good results than in either coal- or water-gas making. For making gas the oil and steam are first turned into the top of the primary. The oil is decomposed by passing downward through the checker brick in the primary generator, thence through the connecting throat piece and up into the secondary generator. Should the gas thus made be permitted to traverse the entire length of the secondary generator to the top, the illuminants would be partly decomposed by breaking down into marsh gas, hydrogen, and lampblack. To prevent this overheating and to protect the gas the outlet of the machine is placed at or near the middle of the secondary generator. Above this point there is a large amount of heat stored in checker brick placed upon a number of arches, sprung across the generator. These arches are durable, because there is no direct combustion of oil in proximity to them. To make use of the heat in the top of the secondary generator coils of steam and oil pipes are

connected with eighteen burners in the corbel work at the top of the secondary. Fifteen of these burners are used for making gas, while three are steam pipes for purging. The gas thus made passes downward and through the side outlet into the wash-box. It will thus be seen that gas is made in two directions, leaving the machine through a common outlet. The reasons for this are obvious.

The accompanying table shows the progress of the blast on the sixteen-foot set at Generator No. 2 Jones, Monday July 26, 1909:

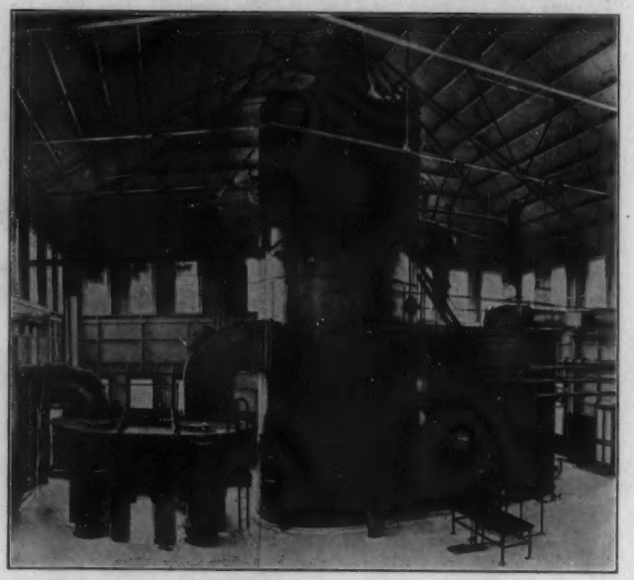
PROGRESS OF BLAST.

Minute	Oil temp., Fahr.	Oil pressure to heat, lbs.	Steam pressure to heat, lbs.	Oil to heat, gallons	Blast pressure, inches
1st			35	blow	9
2d			35	blow	9
3d			35	blow	9
4th	150°	8	35	3.25	7
				3.25	7
5th	150°	8	35	3.50	
				3.50	
6th	150°	8	35	3.25	7
				3.25	7
7th	150°	8	35	3.50	
				3.50	
8th	150°	8	35	3.25	7
				3.25	7
9th	150°	8	35	3.50	
				3.50	
10th	150°	8	35	3.25	7
				3.25	7
11th	150°	8	35	3.25	7
				3.25	7
12th	150°	8	35	3.25	7
				60.00	

Sometimes during the process of heating, it is difficult so to regulate the temperature in the primary and secondary generators, even if the checker brick in both generators are in equally good condition for breaking up the oil. If the gas were taken off at the top of the secondary it would be impossible so to regulate the heat that no oil would be wasted, no gas overheated, or the yield of gas the minute not reduced. By adopting the side outlet all heat is conserved. If the top of the secondary be overheated more oil is used in that part of the machine, and if the primary be at too low a temperature less oil is used in the primary. In this way all heat is used for gas making and practically one is wasted. At the same time a uniform quality of gas is maintained.

One of the best indicators of the quality of gas being made is the condition of the overflow water from the wash-box and from the first scrubber. The presence of tar in the wash-box seal shows that the heat is too low, and lampblack in the overflow from the first scrubber shows that the heat is too high.

The table following shows the amount of oil used in gallons, in different parts of the set, together with the steam and oil pressures, all pressures being on the inner side of the throttle valves and within the machine. These figures were taken from the run after the foregoing heat. The duration of the run was ten minutes. Oil is admitted to the top of the primary, beginning with twenty-six gallons a minute and reduced to nine gallons during the eighth minute. Oil



A 16-Foot Oil-Gas Set with a Capacity of 150,000 Cubic Feet an Hour.

This is called a 3,000,000-foot set; it will produce that amount of gas every day in the year and can be forced to produce 4,000,000 feet. Eight such sets are in operation in San Francisco and Oakland.

is admitted to the top of the secondary, beginning with thirty-nine gallons during the first and ending with twelve gallons during the eighth minute. The steam pressure remains constant during eight minutes of the run. At the end of the eighth minute the oil is shut off from the primary and secondary; and the steam pressure on the primary and secondary is raised to 110 pounds, and is allowed to remain at this pressure for the last two minutes of the run for the purpose of purging the machine. For purging the machine during the last two minutes of the run three special open steam pipes are used at the top of the secondary. Steam is maintained on the burners at the top of the primary and secondary. A one-inch steam pipe admits steam to the bottom of the primary directly opposite the throat piece; this is also for the purpose of clearing the machine.

MAKE OF GAS, JULY 26, 1909.

Minute	Oil temperature, Fahr.	Oil primary, gals. to make	Oil secondary, gals. to make	Oil pressure primary, lbs.	Steam pressure primary, lbs.	Oil pressure sec., lbs.	Steam pressure, sec., lbs.	Boiler steam pressure, lbs.
1st	150	26	39	21	25	27	25	110
2d	150	26	39	21	25	27	35	110
3d	150	18	26	19	25	24	35	110
4th	150	18	26	19	25	24	35	110
5th	145	18	26	19	25	24	35	110
6th	145	17	26	19	25	24	35	110
7th	145	17	26	19	25	24	35	110
8th	145	9	12	19	25	24	35	110
9th	140	purge	purge		110		110	110
10th	140	purge	purge		110		110	110

Following are two analyses of gases taken at the stack valve at the middle of the heating period:

JONES SET No. 2.

Composition.	Percentages.
Carbonic acid	13.1
Oxygen	1.9
Nitrogen	85.0

JONES SET No. 1.

Carbonic acid	15.3
Oxygen	0.2
Nitrogen	84.5

These analyses are frequently taken to determine the ratio of air to heating oil.

According to experiments at Munich in 1880 (Stillman's Engineering Chemistry) 6 per cent of carbonic acid indicates three times the theoretical amount of air required; 9 per cent of carbonic acid indicates two times the theoretical amount of air required; 17 per cent of carbonic acid indicates one time the theoretical amount of air required.

The following table gives the make of gas a minute for a series of five runs. These tests were of necessity on different days so that the gas could be carefully measured in a relief holder isolated for the purpose and careful corrections for temperature be made to avoid error in measurement. The amount of oil used for heating and making and also the total oil used by the thousand feet of gas are given in this table. The make of gas a minute during a ten-minute run is a good indication of the application of the heat contained in the checker brick in the making of gas, and is an index to the proper length of run.

TEST RUNS ON NO. 2 JONES SET.

Min.	July 9	July 10	July 10	July 12	July 12	Average
1st	7,080	6,664	5,206	8,538	7,497	6,997
2d	6,247	7,705	6,872	6,664	9,371	7,372
3d	6,039	7,080	7,082	8,333	7,497	7,206
4th	5,831	6,664	6,247	8,225	7,393	6,872
5th	5,623	6,248	6,248	6,248	6,664	6,206
6th	5,623	6,248	6,247	6,351	5,831	6,060
7th	5,415	6,664	6,248	6,559	6,768	6,331
8th	4,790	2,915	4,165	3,748	3,540	3,832
9th	2,707	2,290	2,082	1,978	2,291	2,270
10th	2,082	1,042	2,082	1,874	833	1,583
Totals	51,437	53,520	52,479	58,515	57,685	54,729
Oil for	Gals.	Gals.	Gals.	Gals.	Gals.	Gals.
Heat	70	70	70	70	70	70
Make	370	373	370	370	400	377
Total	440	443	440	440	470	447
1,000 cu. ft.	8.55	8.28	8.38	7.53	8.13	8.17

Following is a table giving the analyses of the gas made during a run July 19, 1909, on Jones Set No. 2. Samples of gas were taken from the wash-box at the end of the second, fifth and seventh minutes, and analyzed:

Composition.	End of 2d min.	End of 5th min.	End of 7th min.
Carbonic acid gas	1.6	0.8	0.4
Illuminants	3.4	6.6	9.0
Oxygen	0.2	0.2	0.0
Carbonic oxide	9.4	8.0	6.6
Hydrogen	53.2	50.6	44.8
Marsh gas	28.5	30.9	35.0
Nitrogen	3.7	2.9	4.2
B. T. U. the cu. ft.	589.0	665.0	732.0
Specific gravity	.382	.391	.423

The results of a typical run at the Potrero Station, San Francisco, June 4, 1909, giving the amount of gas made, oil used, and an analysis of the gas taken at the outlet of the wash-box during the first minute, when all the gas was made in the primary generator, and during the second, fifth, seventh, and tenth minutes, are shown in the following table, which gives the analyses of samples taken at the outlet of the wash-box of the No. 3 Jones Set.

RESULTS OF TYPICAL RUN.

Composition.	1st Min.	2d Min.	5th Min.	7th Min.	10th Min.
Car. acid	1.8	1.3	0.0	0.0	0.0
Illuminants	8.6	2.1	5.0	5.8	7.8
Oxygen	Tr.	Tr.	Tr.	Tr.	Tr.
Car. oxide	5.6	20.2	9.4	8.2	14.6
Hydrogen	31.7	44.1	46.6	44.9	47.4
Marsh gas	43.4	26.7	35.7	37.3	25.9
Nitrogen	8.9	5.6	3.3	3.8	4.3
B. T. U.	765.0	549.0	675.0	698.0	747.0
Specific gravity.	.514	.469	.402	.411	.435

Minute	Cubic Feet	
1st	5,625	
2d	5,833	Oil 320 gallons to make, 60 gals. to heat; 380 gallons total.
3d	6,041	
4th	5,625	
5th	5,416	8.25 gallons for each 1,000 cubic feet.
6th	5,000	
7th	4,373	7½ minute primary oil off.
8th	4,166	
9th	3,125	8th minute secondary oil off.
10th	833	
Total	46,041	

The percentage of carbonic oxide in these analyses would lead to the conclusion that the carbonic oxide is not formed by contact of steam and the carbon remaining in the generators after a heat.

It will be noticed that the gas made in the primary generator at the beginning of the run contains 5.6 per cent of carbonic oxide, while during the second minute it increases to 20.2 per cent and then drops to less than half that amount during the fifth and seventh minutes, rising again to 14.6 per cent during the tenth minute. The carbonic oxide is undoubtedly produced by the dissociation of steam in contact with incandescent particles of lampblack, which have been thrown down by the breaking down of hydrocarbons.

A fact now well understood is that the oxygen of steam will not unite with carbon in combination with hydrogen, so that neither carbonic acid nor carbonic oxide is generated directly from the hydrocarbons of the oil in contact with steam. First it is necessary to convert the oil into gas or hydrocarbon vapor and then break down the hydrocarbons into lampblack and hydrogen. This lampblack, becoming incandescent, will unite with oxygen of steam. The high percentage of nitrogen in the primary gas is probably due to the presence of a small amount of products of combustion remaining in the primary generator after the heat. The nitrogen diminishes to the fifth minute and then increases to 4.3 per cent during the tenth minute.

California petroleum contains more than 1 per cent of nitrogen; usually 1.1 per cent. This is twice the amount of nitrogen contained in the petroleum of Pennsylvania and West Virginia. In distilling California petroleum the third fraction, taken off between 200° and 250° C., has a strong odor of ammonia. This ammonia is destroyed in the gas generators at higher temperatures, and appears in the gas as nitrogen and hydrogen.

Further to determine the part played by the steam admitted with the oil three runs were made on a sixteen-foot set, first in the ordinary way, second with oil injected under its own pressure without steam, and third by steam without the use of any oil. In each case the test was made after the generator had been heated ready to make gas. And these are the results:

Composition	Ordinary run	All oil	All steam
Carbonic acid	0.4	0.4	43.8
Illuminants	5.2	6.2	0.0
Oxygen	0.1	0.1	0.2
Carbonic oxide	7.0	5.3	10.6
Hydrogen	46.6	47.9	5.0
Marsh gas	30.6	36.7	0.0
Nitrogen	5.1	3.4	40.4
Specific gravity	.404	.388	1.168
B. T. U. a cu. ft.	668.302	700.746	53.55

Ordinary run—Same gauge pressure as combined oil and steam runs; 17-in. pressure inside machine, 47 gals. a minute.

All oil run—18 lbs. to 19 lbs. oil pressure on primary, 25 lbs. to 27 lbs. oil pressure on secondary; 21-in. pressure inside machine; 51 gals. a minute.

All steam run—25 lbs. pressure on heat burners; 26 lbs. pressure on primary make burners; 32 lbs. pressure on secondary make burners; 10-in. to 11-in. pressure inside machine.

The run made with all steam can not be directly compared with the two other runs, as very little gas was produced; barely enough to enable the taking off of a sample at the wash-box. The generator at this period was at the same temperature as during ordinary runs. That is, it was at a temperature high enough to decompose steam in the presence of incandescent carbon, and only 10.6 per cent of carbonic oxide was produced. Had there been much carbon deposited on the checker brick this generator would have been in ideal condition for the manufacture of "blue" water-gas.

As to the California petroleum from which this gas is made, the crude petroleum from 12 degrees to 17 degrees B. is best adapted to the purpose of making gas. This oil has an asphaltum base, as has most of the petroleum produced in California. This makes it in a measure unattractive to oil refiners. The California crude petroleum used during the following experiments was 15.8 degrees B. at 60 degrees F. Distillation began at 85 degrees C.

	Temperatures	Percentages	Color of fraction
No. 1....	Below 150° C.	5.0*	yellowish
No. 2....	150° — 200° C.	4.0	yellow
No. 3....	200° — 250° C.	27.5	lemon with H_2S and NH_2
No. 4....	250° — 300° C.	14.0	lemon
No. 5....	Above 300° C.	39.5	red
No. 6....	Coke	8.0	black
	Loss	2.0	
	Total	100.0	*2¼% water

Flash point, 257° F.
Fire test, 293° F.
After the 300° fraction comes off the temperature rises immediately to above 280° C.

The ultimate analysis of oil taken from this same field is:

Carbon	85.	per cent
Nitrogen	1.	per cent
Sulphur	.8	per cent
Oxygen	1.0	per cent
Hydrogen	12.2	per cent
Total	100.0	by weight

The exact amount of sulphur in the oil used for these experiments was 0.93 per cent.

Oil containing sulphur in quantity less than 1 per cent will produce gas which may be satisfactorily purified by ordinary oxide of iron. Should the percentage of sulphur exceed 1 per cent, purification becomes difficult, unless there is a large purifying capacity provided for it. Crude oils in California in some instances contain as much as 4 per cent of sulphur. It is better not to purchase oils containing so much sulphur as it is necessary to provide elaborate and expensive means for purifying the gas. Fortunately the most available crude oils, produced in greatest abundance and best adapted to oil-gas making, have a small percentage of sulphur. After these crude oils are distilled and the distillates are sold for gas manufacture the distillate contains all of the sulphur of the crude oil condensed into the lesser quantity of distillate.

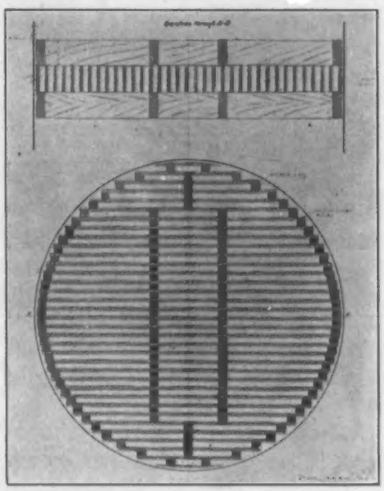
It is the opinion of the writer that a crude petroleum from 14 degrees to 16 degrees B. is the oil which gives the best results in oil-gas making. In other words, the more pounds in weight to the gallon of oil the greater will be the production of gas, and there will be less waste of oil. This is diametrically opposed to good water-gas practice, but the conclusion has been reached after the use in practice and experimentally of crude oils from 8 degrees B. to 37 degrees B. and distillates from 20 degrees B. to 42 degrees B.

The wash-box serves a double purpose as a hydraulic seal and as a piece of apparatus in which nearly all of the lampblack is separated from the gas and held in suspension in the water. The early forms of wash-boxes were comparatively of small dimensions and were filled with baffle plates and partitions, forming excellent lodging places for lampblack, so that the cleaning of the wash-boxes was an important part of the gas-maker's daily work. In the development of a self-cleaning wash-box, to take care of the amount of lampblack made by a sixteen-foot set, it became necessary to depart from the square or circular form and adopt an oval shape, having a superficial area of 265 square feet, also to depart from the usual custom of connecting the generator to the wash-box and the wash-box to the scrubbers with pipe of the same or even smaller diameter than the trunk mains in the gas works. Allowance is made for the expanded condition of the hot gas leaving the generator. In what is known as a twenty-four-inch gas works the inlet and outlet pipes to the wash-box are forty-eight inches in diameter, while the diameter of the dip pipe in the wash-box flares to sixty-eight inches. This removes one of the chief causes of back pressure and enables the hot gas easily to get away from the machine.

In the new form of wash-box there are no partitions or diaphragms, and the space within the box is clear. The gas enters through a dip pipe at one end, and passes out through an outlet pipe from the top of the wash-box at the other end. Two large overflows on the side of the wash-box carry away the lampblack. The self-cleaning principle of this wash-box is in the constant agitation of the water in the box. This agitation is produced by dividing the main water supply into a number of one-inch pipes, twelve in all, extending to within three inches of the bottom of the wash-box. The water is thus forced downward to the bottom of the box, and it rises to the overflow. The lampblack is washed out of the gas by this turbulent water, and is carried out of the box before it has an opportunity to settle. The average temperature of the water entering the wash-box is 61 degrees F., and the average temperature of the water leaving the wash-box is 129 degrees F. The temperature of the gas leaving the wash-box is 142 degrees F., and the amount of water used in the wash-box is forty-six gallons for each thousand cubic feet of gas. The lampblack and water pass from the wash-box through open drains to the lampblack separator.

Thorough scrubbing of oil-gas is all important. It has been proven conclusively that it is better to treat oil-gas directly with a large quantity of water than to use the methods of condensing and scrubbing as applied to coal-gas, where valuable by-products must be removed. Oil-gas requires more water for scrubbing than any other kind of gas, on account of the finely divided particles of lampblack held in

suspension in the gas. These must be removed, as they would tend to destroy the purifying material. Should the lampblack pass through the purifiers it would cause endless trouble by stoppages. One uniform kind of scrubber and one method of filling it have been adopted. The old-style cylinder filled with trays through the top is the best to be had, but the filling should be carefully done. The trays are made of one-inch by six-inch pine lumber surfaced on four sides and nailed together in sections, with spacing pieces one inch thick also made of surfaced lumber. These trays are made in sections small enough to go through a door on the top of the scrubber. Each alternate layer of trays is placed at right angles to the one immediately under it, and the entire shell is filled without voids of any kind. As these trays are made somewhat smaller than the inside diameter of the steel shell, in order to provide for easily getting the trays in and out and for the swelling of the wood, it is essential that the space between the trays and the shell shall be caulked with excelsior, so that the gas can not pass round the trays instead of through them, or the water flow down the inside of the shell. In this way the gas is compelled to pass upward through the trays, meeting smooth wet surfaces; and the water



Trays for 6-Foot Scrubbers.

passes evenly downward through the trays, thus the maximum efficiency is obtained by the use of the smallest amount of water.

A plan of a scrubber tray and the arrangement of the trays in the scrubber are shown in the accompanying illustration. In the larger works there are three scrubbers twelve feet seven inches in diameter by forty feet high, and the water is supplied to them through ten sprays passing through the top head. With each sixteen-foot apparatus the amount of water used is approximately fifteen gallons for each thousand cubic feet of gas for each scrubber, or forty-five gallons the thousand cubic feet for the complete scrubbing of the gas. Salt water is used in the wash-box and in all the scrubbers. It gives satisfactory results, having no deteriorating effect upon the gas or upon the scrubbing apparatus. Salt water has the further advantage, where gas works are located on tide water, of being available in abundance at small cost for pumping, and it can be wasted after it has been used. In small plants, where water is scarce or expensive, it becomes necessary to be more saving in the use of water and in some cases to cool the water and use it over again.

The overflow water containing lampblack flows from the wash-box through open, exposed drains into the lampblack separator. In nearly all oil-gas works the overflow water containing tar from the scrubbers flows into the same separator. The amount of tar is so inconsiderable that it is seldom recovered for sale, but when the tar is mixed with lampblack it adds somewhat to the fuel value of the lampblack and acts as a binder in briquetting.

Separators of small dimensions and containing many partitions have been superseded by those of much larger dimensions with fewer partitions. Experience with the separating of lampblack from water has developed the fact that the greater the area of the separator, and consequent slower speed of flow of water, the more thoroughly is the lampblack separated from the water.

The lampblack-and-water first empties into a separator provided with a constantly moving skimmer, consisting of pieces of 1 x 3 oak fastened to sprocket chains. The light, fluffy lampblack, rising to the surface of the water, is skimmed off by these scraping pieces and taken through a trough to a height of about twenty-five feet, and emptied into a settling tank, the walls of which are made of dry lampblack in the form of the crater of a volcano. After this skimming process the water flows into a separator, an illustration of which is here shown.

Where the Lampblack Is Separated from the Water.

This picture is of a separator recently installed. This separator is capable of separating lampblack from water used in the manufacture of 12,000,000 feet of gas a day. In this separator there is a single partition running longitudinally. The partition is provided with a skimmer extending below the surface of the water. The separator is made in two sections to enable the alternate cleaning and use of the sections. The water containing lampblack flows into one of the large pits, and the separation is accomplished by the settling of the lampblack particles through the water. This process is of necessity slow, because the specific gravity of the lampblack is so nearly that of water. The water passes under the skimmer and over the partitions into the next pit, where further settling takes place. Out of this pit the clarified water passes through an open flume and is wasted. When the two pits are filled with lampblack the water gates are opened into the next pair of pits, and the water is shut

off from the pits filled with lampblack. The removal of the lampblack is then performed by means of a locomotive crane with a clam-shell bucket. The water-soaked lampblack thus removed is deposited in a pile and allowed to drain. After it has drained until there is about 30 per cent of water remaining in it, it may be used as boiler fuel. This was the only use to which lampblack was put in the early days of oil-gas making. Attempts were afterward made to make lampblack briquettes for domestic use. This proved difficult on account of the large amount of water contained in what seemed to be comparatively dry lampblack. It was found that the only simple and practical method of briquetting was by the use of a plunger operated by a crank shaft to force the lampblack into an open cylindrical mold, thus forming an endless briquette, after the manner of a sausage machine. These briquettes would break by their own weight in lengths that were multiples of the length of a stroke. That is, if the stroke of the machine were 1½ inch, the briquettes would break off in lengths of 3, 4½, or 6 inches. This method was found to be slow and expensive. So a vertical press was invented which had four plungers arranged on one shaft. The lampblack was fed through a trough into four molds and pressed by the plungers into and through these molds, breaking off into pieces in the same manner as described of the single horizontal press. This vertical press produced fifty tons of briquettes in twenty-four hours. The briquettes were three inches in diameter, weighed 5.4 ounces the linear inch, or 82½ pounds the cubic foot. They were smooth on the outside and possessed cohesion enough to permit of ordinary handling. The only binder used in the making of these briquettes was the normal amount of tar flowing from the scrubbers into the lampblack separator. Apparently the briquettes were dry when made, but they still contained a considerable quantity of water.

Here is an analysis of a briquette after it had been stored for one year in a dry place:

Moisture	8.5 per cent
Volatile matter	10.8 per cent
Fixed carbon	79.9 per cent
Ash	0.8 per cent
Total	100.0 per cent

These briquettes are an ideal fuel, particularly for use in open grates. Owing to the small percentage of ash, the briquettes when once ignited remain at a glowing heat until they are entirely consumed. The only objection to the use of them is the strong odor of naphthalene which they possess, and which does not entirely disappear after storage for a long time.

In order to avoid the inconvenience of dealing in by-products, it was decided to make the experiment of using lampblack briquettes as a substitute for anthracite coal in water-gas generators. In a station contiguous to the Potrero plant in San Francisco there were six sets of double, superheated, Lowe water-gas apparatus, with a rated capacity of 1,000,000 cubic feet each. Briquettes were used in these sets with some success, but the capacity of the sets was reduced 50 per cent by using lampblack; that is to say, no more than 500,000 cubic feet of gas could be made in a day with a set rated at 1,000,000 cubic feet. But the making of gas in this way had decided advantages; there was an entire absence of clinker, and very little time was required to clean the fires. Contrary to expectations, the air pressure required to blast through lampblack was extremely low, never exceeding nine inches. The average amount of lampblack used the thousand cubic feet of gas covering a period of six months was 39.86 pounds, and the oil used for enriching was 6.8 gallons a thousand. This oil was the ordinary 14° to 16° crude oil with asphaltum base. The candlepower ranged from 28 to 33 candles. At that time the gas supplied to San Francisco was 23 candlepower. The oil-gas, which was made in the large generators, was 19 candlepower. The candlepower of the oil-gas was raised by mixing about 24 per cent of the high candlepower lampblack water-gas with it.

Here is a typical analysis of the lamyblack water-gas:

Composition	Percentage
Heavy hydrocarbons	16.5
Marsh gas	32.8
Hydrogen	24.6
Carbonic oxide	13.7
Carbonic acid gas	6.2
Oxygen	0.2
Residual nitrogen	6.0
Total	100.0
Specific gravity	.647
Net B. T. U. the cu. ft.	814.
Candlepower	28.5

A lampblack fire is apt to flue during the blast, and it requires some care to keep the fuel bed in condition, as shown by the amount of carbonic acid in the gas produced.

In using the lampblack the ordinary round grate bars are placed half an inch apart. Great care is necessary not to overheat the superheater and thus make lampblack in the water-gas apparatus. During the heavy demand for gas during the winter of 1908-9 the use of lampblack exceeded the capacity of the single briquetting press. It became necessary to use lumps of lampblack dug from the side of a pile of dry material. These lumps were of about the same size as the coarse anthracite coal ordinarily used, and were broken away from the pile with pick-axes. It was found that the lumps held their shape fairly well in the generator, and gave fully as good results as briquettes. So lump lampblack was substituted for briquettes in all the generators, thus saving the cost of briquetting and considerably reducing the cost of lampblack water-gas.

Following is a recent analysis of the lampblack used in the generators:

Volatile matter, including moisture.	34.15 per cent
Fixed carbon	65.80 per cent
Ash	0.05 per cent
Total	100.00 per cent

The first lampblack water-gas was made July 14, 1906. This gas has been made continuously, without the use of other fuel in the generators, since May 5, 1907.

The improvements in oil-gas manufacture described in this paper have made it possible to regulate the amount of lampblack produced so that a combination of oil-gas and a lampblack water-gas plant will produce only enough lampblack for boiler fuel and generator fuel, with no product remaining for sale, excepting gas. The amount of lampblack now produced in the largest oil-gas sets is twenty pounds the thousand cubic feet of gas.

For the purpose of showing the average composition of oil-gas, lampblack water-gas, and the mixed gas now made and distributed in San Francisco, the accompanying series of ten analyses of each are given. These analyses were taken at random during each of the dates from June 11th to June 22d, inclusive, so the average of these is a good criterion of the composition of the gas.

ANALYSES AND AVERAGES OF TEN SAMPLES OF CRUDE-OIL-GAS

June	CO_2	C_nH_{2n}	O_2	CO	H_2	CH_4	N_2	C. P.	B.T.U.	Sp. gr.
11th	2.5	7.1	0.2	9.2	40.5	33.8	6.7	18.4	675.	.479
12th	2.5	7.0	0.2	9.3	37.8	35.8	7.4	22.2	686.	.495
14th	2.4	8.0	0.2	9.4	40.0	33.3	6.7	21.2	687.	.485
15th	2.8	6.2	Tr.	9.4	39.0	35.4	7.2	18.5	670.	.487
16th	2.2	6.8	0.2	8.8	40.1	35.5	6.4	20.8	685.	.474
17th	2.4	7.0	0.2	8.4	42.8	34.2	5.0	18.8	683.	.456
18th	2.4	7.0	0.2	9.4	38.7	35.1	7.2	18.7	681.	.489
19th	3.0	7.2	Tr.	9.8	39.1	34.7	6.2	19.7	684.	.490
21st	3.0	6.8	0.4	9.4	40.2	33.5	6.7	18.4	665.	.481
22d	3.0	7.0	Tr.	9.0	39.6	35.1	6.3	20.2	683.	.484
Av.	2.62	7.01	0.16	9.21	39.78	34.64	6.58	19.69	679.9	.482

ANALYSES AND AVERAGES OF TEN SAMPLES OF CARBURETTED WATER-GAS

June	CO_2	C_nH_{2n}	O_2	CO	H_2	CH_4	N_2	C. P.	B.T.U.	Sp. gr
11th	5.6	17.0	0.2	14.0	26.0	31.6	5.6	32.5	816.	.636
12th	5.6	16.8	0.2	13.4	23.8	34.7	5.5	32.2	836.	.643
14th	5.4	17.0	Tr.	13.6	27.0	32.0	5.0	33.1	822.	.624
15th	6.0	17.0	Tr.	13.0	25.6	33.6	4.8	30.5	833.	.633
16th	5.6	16.2	Tr.	13.6	24.4	33.4	6.8	29.1	812.	.643
17th	5.7	16.3	Tr.	13.2	25.2	33.5	6.1	29.5	817.	.635
18th	6.0	16.0	Tr.	13.0	25.3	33.6	6.1	28.3	812.	.636
19th	5.8	16.0	Tr.	14.2	24.9	32.0	7.1	28.8	797.	.645
21st	5.5	15.5	0.2	13.8	25.3	32.5	7.2	30.3	793.	.638
22d	6.0	16.0	Tr.	14.0	23.5	34.1	6.4	30.4	814.	.650
Av.	5.72	16.38	0.06	12.58	25.10	33.10	6.06	30.47	816.2	.638

ANALYSES AND AVERAGES OF TEN SAMPLES OF MIXED CRUDE-OIL GAS AND CARBURETTED WATER-GAS

June	CO_2	C_nH_{2n}	O_2	CO	H_2	CH_4	N_2	C. P.	B.T.U.	Sp. gr.
11th	3.4	9.2	0.4	11.0	37.2	32.9	5.9	21.8	703.	.518
12th	3.5	9.7	0.4	9.8	36.6	33.2	6.8	22.9	710.	.522
14th	3.4	10.2	0.4	10.0	36.3	33.6	6.1	22.9	724.	.523
15th	4.0	10.0	0.4	10.6	35.8	32.5	6.7	21.4	708.	.535
16th	3.5	9.3	0.4	10.2	38.3	31.9	6.4	21.6	696.	.512
17th	3.4	9.6	0.2	10.0	36.7	34.6	5.5	20.9	724.	.515
18th	3.6	10.0	0.4	10.9	37.2	32.3	6.5	21.5	709.	.521
19th	4.0	9.6	0.2	10.6	34.5	34.0	7.1	22.1	712.	.540
21st	3.8	9.7	0.2	10.0	35.6	33.7	7.0	21.7	712.	.531
22d	3.7	9.7	0.4	10.2	37.2	32.9	5.9	22.0	710.	.519
Av.	3.63	9.70	0. 34	10.24	36.54	33.16	6.39	21.88	710.7	.5236

The amount of gas made and the percentage of oil-gas and of water-gas involved in the immediately preceding analyses are given in the following table:

June	Oil-gas made M	Water-gas made M	Per cent oil-gas	Per cent water-gas
11th	6,921	2,095	77	23
12th	7,094	2,089	77	23
14th	6,664	2,090	77	23
15th	6,522	2,090	76	24
16th	7,054	1,975	78	22
17th	5,976	2,102	74	26
18th	6,072	2,102	74	26
19th	6,718	2,077	77	23
21st	6,742	2,097	76	24
22d	5,869	2,060	74	26
Average	6,563	2,077	76	24

The early days of oil-gas were filled with doubts as to whether it could ever take the place of coal-gas or water-gas. Doubters prophesied that the gas would not be fixed and that it would be impossible to maintain uniformity in candlepower. These doubts and fears have all been allayed. Oil-gas as now made in California has the same stability as well-made coal-gas, with the further advantages that any desired candlepower may be maintained and that naphthalene stoppages can be practically controlled from the station.

An examination of the coroner's records shows that nearly all of the deaths from gas asphyxiation were suicides. This leads to the thought that when it became known that illuminating gas containing much carbonic oxide was a simple and convenient means of suicide gas became popular with suicides. The introduction of oil-gas immediately dropped the percentage of carbonic oxide to less than 7 per cent, and deaths from gas asphyxiation became rare. There followed many unsuccessful attempts at suicide. Persons deliberately turned on the gas in closed rooms, but, after remaining under its influence for several hours, were easily resuscitated. A great many instances of this kind seemed to discourage the use of gas as a means of suicide. The subsequent improvements in oil-gas that increased the percentage of carbonic oxide to 9 per cent and the addition of lampblack water-gas that further increased it to between 10 and 11 per cent have not increased the mortality from gas asphyxiation. This would seem to prove that very few deaths from gas asphyxiation are purely accidental.

The question now naturally arises, In what localities can oil-gas be made a commercial success? This depends primarily on the cost of oil. As oil-gas can be made in large or moderate size machines, with nine gallons of oil or less, the cost of oil the thousand cubic feet may be easily calculated from the cost of oil the barrel delivered in any given place. Next is the item of labor. In California, and particularly in San Francisco, labor is strongly unionized, and the wages of the men employed in gas works are much higher than in other parts of the country. The hours of labor are invariably eight a day, so that it requires three shifts of men to operate any gas-making apparatus. Gas-makers received $110 a month, their helpers $90 a month, and no ordinary laborer is paid less than $2.50 a day for eight hours' work. With these high prices for labor prevailing, it is imperative that the largest units for gas making shall be employed. The large generators herein described have accomplished great saving in the cost of labor in gas making.

During December, 1908, at the Potrero station in San Francisco, the amount of gas made was 267,792,000 cubic feet, and the cost of labor the thousand was as follows:

Generator labor, including gas-makers, helpers, and all men on the floor	$0.00811
Labor handling lampblack by hand (This was before the installation of the crane for handling lampblack)	.00585
Estimated cost handling lampblack by crane	.00333
All purification labor	.00491

During June, 1909, the total make of gas was 170,776,000 cubic feet.

Labor in the generator room	.00994
Handling lampblack	.00522
Purification wages	.00624

The miscellaneous labor about the works, including firemen, water tenders, engineers, helpers, other mechanics, and office help, is about the same as in any economically operated water-gas plant where no residuals are handled. The improvements in labor-saving apparatus in oil-gas making have thus kept pace with the increase in wages and the reduction of hours of labor, so that the present system of gas making is most economical, notwithstanding the obstacles presented by local conditions.

The future of oil-gas depends largely upon the price of oil and the practice of economy in the manufacture of gas. The price of oil may be regulated by a gas company owning its own source of supply of oil, and the practice of economy rests in the hands of every conscientious worker in the gas industry.—*American Gas Institute.*

THE WATTHOUR METER.

BY WM. M. SHEPARD AND ALLEN G. JONES.

CHAPTER VII.

(Continued.)

Shop Methods of Testing.

A very convenient and flexible laboratory testing board is shown diagrammatically in Fig. 96, which can be used for testing single phase watthour meters of voltages from 100 to 500 inclusive, and of any ampere capacity, the load being regulated by switching more or less of the lamps in circuit by means of the single pole switches, L. The indicating wattmeter may be of 5 or 10 ampere capacity, and can be conveniently mounted in a horizontal position on a swinging bracket; the current transformer being of a 5 or 10 to 1 ratio, or if desired, several current transformers of different ratios may be used. For testing 110-volt watthour meters of capacities not greater than the capacity of the indicating wattmeter, the d.p.d.t. switch S″ is thrown in the downward position, thus putting potential on the 100-volt tap of the indicating wattmeter and on the potential winding of the watt hour meter through the variable resistance; at the same time the t.p.d.t. switch S′ is thrown down, thus connecting the

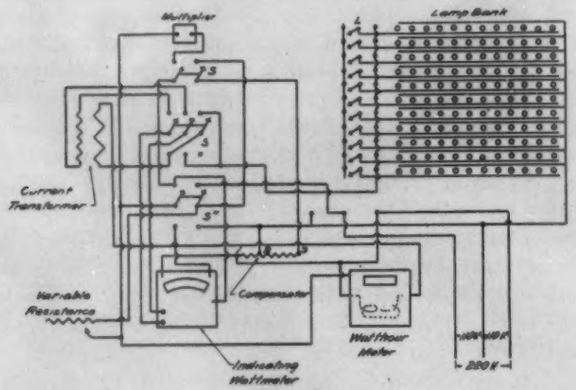


Fig. 96.

indicating wattmeter directly into the circuit. By throwing S′ up, the current transformer is connected into circuit when it is desired to test higher capacity meters. The correct load, as near as possible, is obtained by closing the switches L, and a finer adjustment is accomplished by means of the variable resistance shown in the diagram. This variable resistance is most conveniently made up by wrapping a bare resistance wire on a suitable mandrel and having a sliding contact which will not interrupt the circuit in passing from one turn of the wire to the next. By means of this variable resistance, the tester can hold the load on the wattmeter constant while the test is being made.

For testing 200-volt meters, the switch S″ is thrown in the upward position, and S′ is thrown down or up according to whether the meter in test is below or above the capacity of the indicating wattmeter.

For testing 500-volt meters the switch S is closed, which puts the potential winding of the watt hour meter directly across the 500-volt tap of the compensator, at the same time putting the potential coil of the indicating wattmeter across the 500-volt circuit in series with the multiplier.

In testing meters on loads of low power factors, suitable reactances can be substituted for the ordinary lamp bank (arc lamp reactances can sometimes be conveniently used for this purpose), or the potential windings of the meter may be excited from a different phase of a three-phase system from that which is supplying the load; in this case the power factor will be 50 per cent, and may be either lagging or leading, depending upon which phase is used for exciting the potential winding. In lagging the meter for low power factors, a two-phase system may be used, exciting the potential winding from one phase and furnishing current from the other, in which case the disc should remain stationary with full load current flowing.

In order to determine which phase of a three-phase system to use for exciting the potential windings to get a lagging power factor, and which phase to use in order to get leading power factor, simply connect a small reactance coil in the place of the lamp bank (if such a load is employed), and then connect the potential winding of the meter first to one phase and then to the other. The meter will run slower on the phase giving a lagging power factor.

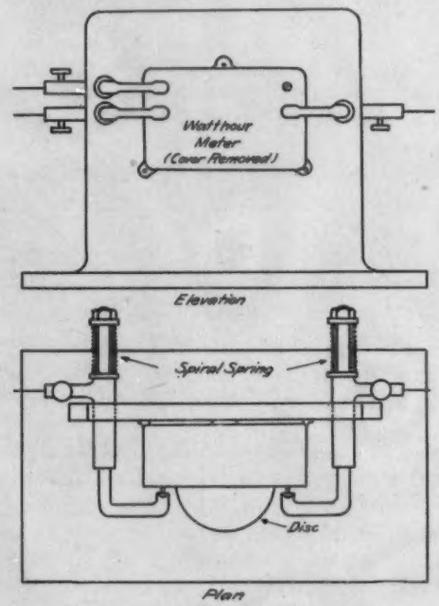


Fig. 97.

Where a great number of watthour meters of the same type are to be tested (such as is the case with large distributing companies in testing new meters), the testing stand shown in Fig. 97 permits of very rapid work, since a meter can be hung in place and connections made within three or four seconds. The stand consists of a wooden base about 2 x 1½ ft., upon which is mounted another vertical 2-in. board of about the same dimensions. Fig. 97 shows the elevation and plan views. Three "L-shaped" terminals are brought out through the vertical board, the spiral springs being used to press the terminals firmly against the binding screws of the meter's connection block.

Another method, employing a connection board essentially the same as shown in Fig. 96, is shown diagrammatically in Fig. 98. Instead of using a lamp bank for loading the watthour meter in test, a "phantom load" transformer, T, is used, the secondary of

which is capable of supplying a heavy current at a very low potential, thereby necessitating only the small resistance coils, L, for regulating the load. This

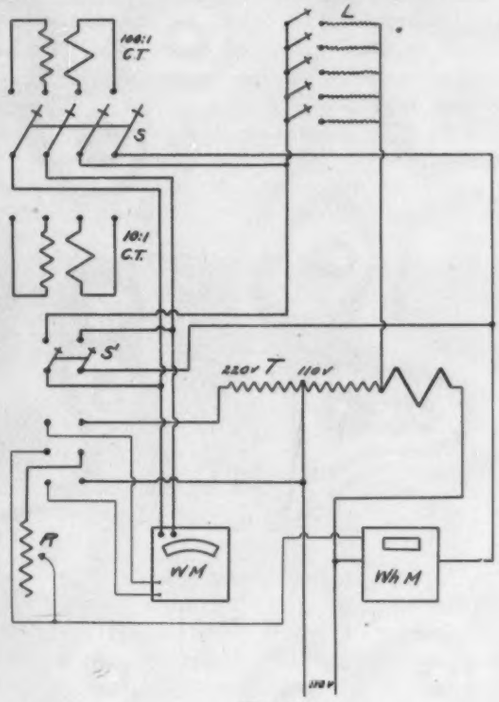


Fig. 98.

method requires only a small amount of power even in the case of large meters, and is therefore very economical.

Testing Polyphase Meters.

In testing polyphase watthour meters, it is usually most convenient to adjust and test them on a single-phase circuit as simple single-phase meters; a polyphase meter so tested will then be correct for polyphase work. The current coils may be connected in series and the potential coils in multiple for testing as a single-phase meter; when tested in this way the constant of the meter should be divided by two, since the current is passing through both elements and is consequently being registered twice. A balanced reading should be taken on both elements as follows:

Potential should be put on both elements and a load put on the current coil of one element, the number of revolutions which the disc makes in a given time being noted; the current coil of this element should then be disconnected and that of the other element connected in the same manner with the same load applied for the same length of time, the revolutions of the disc again being noted. The revolutions of the disc in each instance should be exactly the same, and if any variation is found, the element whose speed is incorrect should be adjusted as described in Chap. III.

A better method of testing polyphase meters is to apply polyphase potential to the potential windings exactly as will be the case when the meter is in service. With such connections, a load is placed on one element and the meter tested as though it were a single phase meter, using the disc constant as stamped on the disc (divided by the ratio of the current transformers times the ratio of the potential transformers). The load should then be taken off of this element and the other loaded, by means of which a "balanced" reading can be obtained, proper adjustments being made if the elements do not balance. The advantage of testing the meter with polyphase potential applied to the potential windings is that the interference of the potential winding of one element with that of the other will be normal, and can be compensated for to great extent in the calibration of the meter.

A three-phase, four-wire meter can be tested exactly the same as a three-phase, three-wire meter by using the two current windings which are wound one on each element, leaving the third current winding open-circuited. The third winding is wound on both elements and when such a meter is tested on single-phase current with both potential coils connected in multiple the meter will run at double speed when this winding is carrying the load.

Polyphase meters should always be calibrated for 50 per cent power factor as well as for unity power factor, since they are almost always used upon circuits which at times operate under low power factor conditions.

Meters Used With Current and Potential Transformers

When watthour meters are used in connection with "current," or "series," transformers, there are two possible sources of error which may ensue; one being due to the angular displacement between the primary and secondary currents of the transformer (this displacement should be exactly 180 degrees), and the other is due to the varying ratio of the transformer at various loads. The first of these two sources of error is negligible except in the case of low power factors, and is largely compensated for by the angular displacement introduced by the potential transformer, as will be explained later in this chapter.

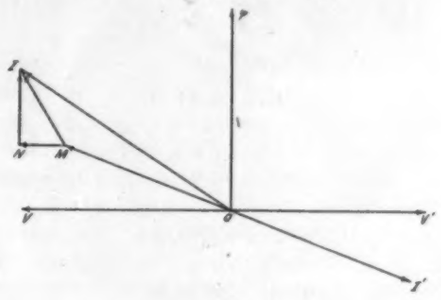


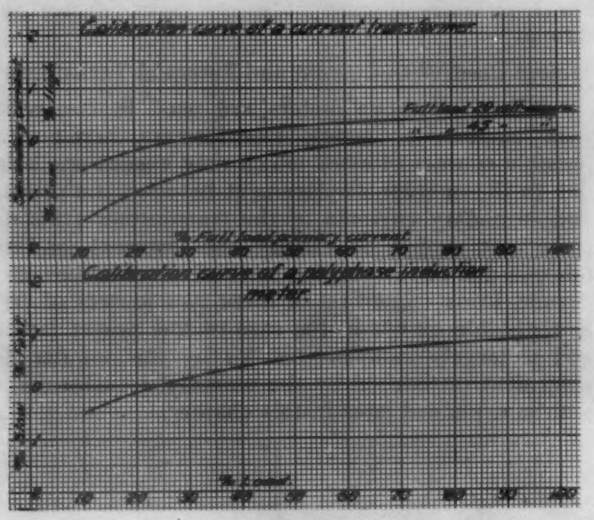
Fig. 99.

Fig. 99 is a vector diagram showing the phase relations of the currents in the primary and secondary of a current transformer; IM is a component of the primary, or line current which acts as exciting current for the transformer and is responsible for both errors above mentioned. In the figure,

OI = the primary or line current,
OI' = the secondary current,
Oϕ = the magnetic flux in the transformer core,
OV = the voltage of primary winding,
OV' = the voltage of the secondary winding,
IN = the magnetizing current,
NM = the **energy** component which supplies the losses of the transformer and the load.

One source of error is due to the fact that OI is not exactly 180 degrees displaced from OI', and therefore the current which flows through the meter (from the secondary side), will not have the proper phase relation with respect to the current in the potential coils of the meter. As already stated, however, for all practical purposes the error thus introduced is negligible except in the case of low power factors, and in transformers of poor design. It can be seen by referring to the above diagram that if the secondary circuit has the proper amount of inductance to cause the secondary current OI' to lag by the same angle that the exciting current, IM, lags, that the secondary current will be exactly 180 degrees out of phase with the primary current, which would result in there being no error from this cause.

The second error referred to, which is caused by the varying ratio of the transformer, is due to the exciting current, IM, not being effective in inducing current in the secondary winding; the secondary current being induced by the component, OM, of the



Figs. 100 and 101.

primary current. If IM varied directly as the primary current, this error could be corrected by adjusting the ratio between the primary and secondary turns; such is not the case, however, and an error is introduced. Fig. 100 is a curve showing the accuracy of a well-designed current transformer. In calibrating watthour meters for use in connection with current transformers, the meter should be calibrated to register correctly on the flat part of the curve. There will then be a slight error at either end of the curve, that is, there will be an error on very light loads on or overloads, but if the meter is carefully calibrated in accordance with the curve of the transformer it will be accurate over the greater part of the range, and the error at either extreme will be small.

Fig. 100 shows a typical calibration curve of a good current transformer, and Fig. 101 shows the calibration curve of a standard induction watthour meter. These two curves are combined as shown in Fig. 102, the resultant curve, B, being the resultant calibration curve of the meter when used in connection with the transformer. It will be seen that if the meter is adjusted so that it will be a little slow on full load (about 0.5 per cent), and if the light load adjustment is set so that the meter will be slightly fast (about 0.5 per cent) on 10 per cent load, the resultant curve will be more nearly correct, and when a high degree of accuracy is required, this is recommended, the amount of such adjustment being determined by referring to the calibration curve of the transformer with which the meter is to be used.

It should be remembered that a current transformer must always have a load on its secondary side; if the meter or instrument with which it is being used should be disconnected while current is still on the

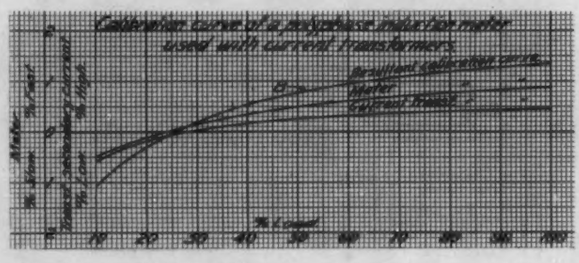


Fig. 102.

primary, the transformer should either be disconnected from the line, or else have its secondary short-circuited. If the secondary is left open-circuited there will be no counter magneto-motive force from the secondary, consequently the magnetic flux will increase to such a degree that it will cause the iron core to become overheated to an extent that may injure the transformer.

The load carried by potential transformers is constant, and if the load is light, the error in the transformer ratio will be very small. The secondary e.m.f. of the potential transformer leads the primary

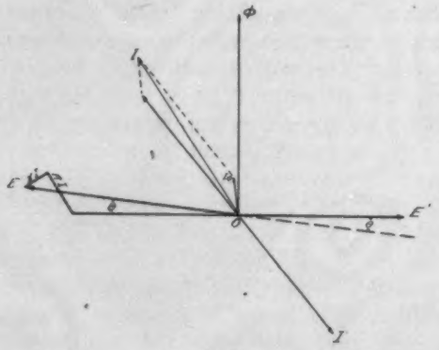


Fig. 103.

e.m.f. by a small angle, θ, Fig. 103; the angular displacement referred to in connection with current transformers is also leading; it therefore follows that the angular displacement in a potential transformer compensates, in a large degree, for the angular displacement in the current transformer; if this angular displacement is the same for both the current and potential transformers the error from this source will be entirely eliminated from the meter with which they are used.

The angular displacement referred to depends upon the magnitude and character of the load imposed upon the transformer, as well as upon its design.

Fig. 103 shows a vector diagram of the regulation of a potential transformer, in which

OE=primary e.m.f.,
OE'=secondary e.m.f.,
OI=primary current,
OI'=secondary current,
RI=total resistance drop,
XI=total reactance drop,
θ=angular displacement between primary and secondary e.m.f.'s.

In using 5-ampere 110-volt meters with current and potential transformers and leaving the regular register on the meter it is necessary to use a multiplying constant, which, multiplied by the register reading, gives the kilowatt hours consumed. This multiplying constant is obtained by multiplying the ratio of the current transformer by the ratio of the potential transformer.

In order to obtain a multiplying constant of 10, 100 or 1,000 it is often necessary to use a special register and to change the disc constant of the meter. The new disc constant is obtained from the following formula:

$$K = \frac{100 \times \text{register ratio} \times \text{transformer ratio}}{10{,}000 \times C}$$

in which C is the multiplier of 10, 100 or 1,000.

Applying the above formula to an example we will take the case of a 5-ampere meter having a disc constant of K=.3, and used with a 20 : 1 ratio potential transformer and a 24 : 1 ratio current transformer, from which the "transformer ratio" in the formula will be (20 x 24)=480 : 1. Suppose a register is chosen having a ratio of 66 2-3, and a multiplier (C) of 100 is used. Substituting these values in the above formula we derive a value of K=.312, which should be used instead of K=.3, which would of course result in a slightly different operating speed of the disc.

(To be continued.)

HOW ANTONE DID IT.

(BY ANTONE'S BROTHER.)

Once upon a time, a little later than the time when the greatest of men did the water stunt, there happened to be a large company operating a smelter, principally by electric current, which was generated by a steam plant. Motors were used to drive the blowers for converters, and the molten ore was conveyed from the furnaces to the converters by electric driven cranes. The whole plant was situated in an arroyo, or small creek, and a large flood came down said arroyo or creek one night and the next day found the engine, boiler and dynamo rooms flooded with water, leaving about five feet of nice oozy mud in them. Fortunately, by hard work they managed to keep the water away from the furnaces and converters, which were on a little higher ground.

The chief engineer in charge of the electrical plant was a rather tony appearing gentleman, by the name of H. E. Doe, E .E. M. A., etc., which might not be his right name. Now, after Mr. Doe had spent some time in careful meditation, he solemnly informed the superintendent that the plant would not be able to start for at least six weeks, and as the ore would remain melted in the furnace probably three or four days, it meant that it would require about as long to get the ore out of the furnaces as it would to repair the electrical end of the plant.

The superintendent did not know anything about the electrical end of the business, but he did know Brother Antone, and where he was to be found. He wired him his troubles, and told him to come at once, which he did. The railroad station was some distance from the smelter, and when Brother Antone arrived at the station, he was met by a tall, lanky gentleman wearing gold-rimmed side lights, latest high-top boots, and the latest type in khaki, who introduced himself to Antone graciously, informing him that he was the chief engineer of the smelter, and volunteering the name of his alma mater, politely requesting the same information from Antone. Upon being informed that Antone was an orphan, he gave him a very patronizing look and commenced to tell him how he would go about getting things in shape, which was continued until they arrived at the smelter, where they found the superintendent making preparations to let the charge of the furnaces run on the floor which had some water on it. This might mean several thousand dollars' damage, to say nothing of the danger to life, but he was preparing for the last resort. Brother Antone advised him to wait a while until he looked around, and after a visit to the dynamo and engine rooms Antone advised him that he would have things in operation in twenty-four hours, when he told Brother Antone to get busy, which he did as follows:

There was several hundred cords of four-foot cordwood near the engine-house, and he started a bunch of men building a crib in the mud around the fronts of the boilers, filling in the chinks with gunny sacks, filled with hay, doing the same around the engines and dynamos, and as soon as he got the cribbing above the mud, put the men to dipping the mud out, starting fires in the boilers as soon as he got the mud out of the cribbing.

When the mud was removed from around the engines and dynamos, he took a hose and began to wash them down, as it would have required a couple of weeks' time to dig the mud out of the armature and field winding, and even after the job was done, more than likely the machines would have to be reinsulated.

The chief engineer began to object, graciously informing him that the machines would be ruined, but the superintendent preferred to take a chance on the electrical end, rather than lose some ten to twenty thousand on the other end, which he knew would be the case. So Antone went ahead.

After washing down the machines, steam was high enough to start them, which Antone did; and what the chief engineer thought was still worse, he short-circuited all the machines by putting a jumper across the terminals. But he ran the machines, which were 220 d.c., just fast enough to make as heavy a current flow as he thought they would stand, when immediately they began to steam and in about ten hours were dried out enough, so he put on a light lead for four hours or more, when he informed the superintendent that the machines would carry the power circuit, which they did.

EFFECT OF SUPERHEATED STEAM ON CAST-IRON AND STEEL.

BY JOHN PRIMROSE.

During the past eight years the writer has been in close touch with many plants, upwards of fifteen hundred installations using superheated steam, and in such a position that troubles would be promptly reported to him. Almost without exception these plants use cast-iron fittings in their pipe connections. The fact that no one of these plants ever reported troubles with their cast-iron fittings does not at all agree with the comparatively few instances where superheated steam has been charged with being the cause of trouble. In order that there should be no doubt about the absence of trouble due to superheat, letters were written to ten concerns known to have been passing superheated steam through cast-iron fittings for the past eight years, asking the following questions:

1. Are the tees and elbows and valves in branch and main steam lines leading from the boilers of cast-iron?

Seven answered yes; two replied that some fittings and valves were of cast iron and some of cast-steel, and one replied that the fittings were originally cast-iron, but that some tees had been changed to cast-steel, but stating positively that the change was not made because of any ill effects of superheated steam.

2. Are fittings of extra heavy or standard weight?

Nine replied that they used extra heavy fittings, and one standard weight.

3. What steam pressure do you ordinarily carry?

One used steam pressure of 100 pounds; six used 150 pounds; one used 165 pounds; one used 185 pounds and one used 200 pounds steam pressure.

4. Have you ever noticed any injurious effect of the superheated steam on valves or fittings?

Eight answered no; one that no trouble was experienced in fittings, but that valves with cast-iron bodies and brass seats were difficult to keep tight, and one reported no trouble further than the baking of a hard deposit on inside.

5. Have you ever found it necessary to replace any of these valves or fittings with cast-steel?

Eight answered that no fittings or valves had ever been replaced on account of superheated steam. One answered that they had replaced no fittings, but some globe valves, and one answered that they were replacing some fittings with cast steel, but upon further inquiry it was found that this was not because of ill effects of superheat, but because the steam mains were being changed to Van Stone Joints and they wished to change the fittings to standard length and deemed it advisable to use cast-steel.

6. Of what material are the gaskets in the steam line?

Seven used corrugated copper or bronze; two sheet packing, and one asbestos.

Ten letters were written and the answers are as reported above. Doubtless further inquiry would result in similar reports. Nearly all of the people written to have used superheated steam for eight years or more, the steam temperature corresponding to from 100 to 150 degrees of superheat.

The chief engineer in charge of a plant in the Middle West, of some 20,000 hp. writes that nothing has developed in any of the cast iron fittings to show that they are in any way effected by the use of superheated steam. This plant has been in operation about five years.

Such evidence as the foregoing proves pretty conclusively that superheated steam does not have an injurious effect on cast-iron. There seems to be no very good reason why it should. Several cast-iron fittings have failed when passing superheated steam. There is nothing extraordinary about this, and the failures are probably due to inferior metal, or to strains developed by expansion or contraction of the pipe lines, as suggested by Professor Hollis and Mr. Mann. These are much more plausible theories than that superheated steam at a temperature of 500 to 600 degrees Fahr. has any effect on the metal. Investigations by Mr. Outerbridge and and Professors Rugan and Carpenter, on the growth of cast-iron when repeatedly heated, start at 900 degrees C., 1652 degrees F. Such instances as the growth of grate bars, etc., are all at temperatures far exceeding anything used in superheated steam work for power plants. Samples of cast-iron taken from fittings passing superheated steam for years have been polished and micro-photographed before and after etching, and compared with samples treated in the same way, taken from fittings passing saturated steam. The expert report is that there is no evidence of a change in the carbon conditions, or of exposure to superheated steam, and in support of this a well-known foundryman gives his opinion that a temperature below 900 degrees Fahr. would not produce any effect in cast-iron. The tests of the famous Crane valve so often quoted are no proof of superheated steam being responsible for the failure. Test bars from the broken valve was compared with test bars taken from the same heat the valve was made from, and the valve was said to have weakened. This is no real test, because castings from different parts of the same heat, or, in fact, different parts of the same casting are known to vary in strength, and it is quite likely that fittings passing saturated steam, if compared on the same basis, would be found to have suffered greatly from the effect of saturated steam. It is unquestionably true that this valve must have been subjected to other influences besides superheated steam. It is rather remarkable that the body of the valve is said to have been weakened more than the flanges—the reason given is that the metal of the body was nearer the superheated steam. Is it not more reasonable to suppose that the metal of the body weakened more than that of the flanges, because it was supbjected to greater fatigue on account of expansion and contraction of the pipe?

Care should be exercised in the design of pipe lines to guard against over strain of the fittings from movement of the pipe due to expansion and contraction. Where long radius bands are the means of taking up this movement, pipe of the lightest possible weight consistent with safety should be used, thereby lessening the strain required to spring the pipe.

A better way of taking care of expansion than long radius bends, is to use ball and socket expan-

sion joints, which have the additional advantage of reducing the amount of piping.

The writer entirely agrees with Professor Hollis in charging strains due to expansion and contraction with the failure of certain fittings, and with Mr. Mann when he charges inferior fittings with the cause of failure in other cases and recommends the use of a good cast-iron containing a percentage of steel scrap for fittings passing superheated steam, as it is entirely in accord with the writer's experience.

THE MECHANICS OF THE STEAM ENGINE.

In its simplest form the steam engine consists of two chains of moving parts on links. One chain of links consists of the crank, which turns about the shaft and constrains the motion of the crankpin, the connecting rod, the crosshead and piston, which move as a unit, and lastly, the engine base, to which the various motions of these links are referred. The other chain of links is identical in action and consists of the eccentric, the eccentric-rod and the slide-valve, together with the base.

The first mentioned chain constitutes the driving mechanism of the engine and serves to transmit the motion which the steam imparts to the piston, a motion of rectilinear translation to a motion of pure rotation, which may be taken from the shaft by means of a pulley and belt, or maybe imparted directly to the rotating element of a dynamo.

The second chain of links is the controlling or actuating mechanism which serves to determine the nature and amount of the force which the steam imparts to the piston. This chain re-transfers the rotary motion of the shaft back to a translatory motion peculiarly related to the motion of the piston.

It is the purpose of these papers to investigate, first, the positions of the various links of each of the above chains when one link—as, for instance, the crank—has a certain assumed position, and then to discuss the relative velocities of the several links corresponding to this assumed position of the crank, and lastly to derive the accelerations—or changes in velocity—which the links are at such instants undergoing.

Since force is always necessary to produce acceleration in the mass of any material, it is but a natural step to the investigation of the forces and strains existing in the materials of which the links are constructed, and it is this knowledge of forces, together with the provisions for safety and yet efficiently constraining them, which makes the engineer of value to his employer.

As these papers are to be written primarily for the operating stationary engineers it will be our aim to avoid the use of higher mathematics, favoring in their stead such graphical analyses as are available.

In Fig. I the line M to B represents the base of a piston-crank chain of links. CO is the crank with shaft at O, W is the crosshead, the motion of which is identical with that of the piston; and WC the connecting-rod.

To determine the position or path of successive positions occupied by any point for assumed positions of, say, the crank pin, it is merely necessary to draw out to scale the various parts for such assumed positions. It is obvious that the successive positions of the crankpin will describe the circle CGBHA about the shaft O, and other points on the crank will describe smaller concentric circles. The point C being common to both the crank and the connecting rod, the rod at this position must likewise describe a circle.

The crosshead W has a motion of translation, the limits of which are shown at M and N, and the distance of travel being equal to AB or double the crank throw. The successive positions of the crosshead for the various positions of the crank pin in its circular orbit may be found by laying the various lengths out to scale on a drawing board and actually measuring the travel MW. A simpler method of determining this value is by the use of the arcs AA′ and BB′ drawn with a radius equal to the length of the connecting rod. By drawing a horizontal line through the crank pin C the distance A′C to the curve will always be equivalent to the travel of the crosshead from the head end of the stroke. The distance CB. is, of course, the corresponding travel from the crank end of the stroke. It will be noted that when the crank has passed through 90 degrees of its travel from the head end dead center, or A, that the crosshead will have traveled through a distance AG, which is considerably greater than the remaining distance GB to the crank end dead center.

In the diagram AD representes the longitudinal travel of the point C or crank end of the connecting rod.

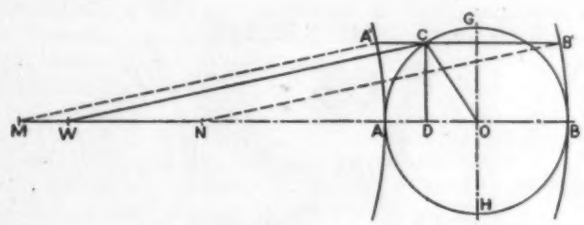


Fig. 1.

Since the motion of one end of the rod is one of pure translation and the other end travels in a circle, the intermediate points will travel in ellipses, which will vary between the two extremes of a straight line and a circle.

The path of any such intermediate point may be determined by laying out successive positions of the parts, and connecting the points so determined with a smooth curve.

By erecting a perpendicular at A and drawing an arc from C to the line MB., such as would be described by the crank end of the connecting rod were it disconnected and let fall, the horizontal distance between such perpendicular and this arc would represent the horizontal travel of an equally elevated point in the rod.

All these relations of position, while very simple, are essential to a thorough understanding of the velocity and acceleration diagrams which will be taken up hereafter.

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NOTICE TO ADVERTISERS

Changes of advertising copy should reach this office *ten days in advance of date of issue.* New advertisements will be accepted up to noon of Monday dated Saturday of the same week. Where proof is to be returned for approval, Eastern advertisers should mail copy at least thirty days in advance of date of issue.

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Newspaper Jargon

Electricity is now so widely used that its technical terms, hitherto sacred to the scientist, are becoming an integral part of our common speech, especially through the medium of the daily press. Unfortunately, the average newspaper man knows but little about the electric power that takes him to his work, brings him his news, lights his office, operates his linotype and prints his paper. The vagueness of his writings reflects and transmits his ignorance to his readers, who thus unconsciously acquire much misinformation.

How often do we read of "an electric current of ten thousand volts"! It would be just as sensible to speak of water of one hundred pounds, heat quantity of one hundred degrees or money of six per cent when we intend to convey the idea of amount. The correct words denoting quantity which should be used in these connections are an ampere of electricity, a quart or a cubic foot of water, a British thermal unit or a calorie of heat and a dollar or a cent of money. Each of these quantities has no energy or can do no work, which is merely energy applied to a particular purpose until it is moved by some force, such as the voltage of electricty, the heat of water, the temperature of steam or the interest of money.

Energy is an eternal Proteus, indestructible, yet ever assuming new forms. The chemical energy in the cell of a battery is converted to electrical energy, which, in turn, becomes thermal, mechanical or radiant, at our will; the radiant energy in light is transformed to chemical energy in the photographic plate, thermal energy in the conservatory, mechanical energy in the radiometer and electrical energy by indirect means. It is not, however, until energy or work is performed for a definite time that it becomes measurable as power. One ampere under a pressure of one volt for one hour gives the watthour; ten cubic feet per second under a head of ninety feet gives about one hundred horsepower, which is also approximately the power necessary to heat one pound of water seventy degrees Fahrenheit in one second; one dollar at five per cent interest compounded semi-annually has the power of two dollars after fourteen years. Many other examples can be cited, but we believe that these clearly demonstrate the difference between an ampere, a volt, a watt and a watt-hour, or in other words the distinction between a quantity, a force, its energy and its power.

It is argued that common acceptance of a word's definition constitutes sufficient evidence as to its correctness, but this criterion should not be applied to technical words of recognized meaning which may find place in colloquial English. Anyone guilty of loosely using such definite terms not only subjects himself to well deserved ridicule, but also displays his ignorance of a matter upon which he is dependent for many modern conveniences.

PERSONALS.

C. E. Wiggin of John R. Cole & Co. is at Seattle.

E. G. Williams, an electrical engineer of New York City, is at San Francisco.

W. J. McCabe, an electrical engineer, recently arrived at San Francisco from Duluth, Minn.

William H. Hoops, an electrical engineer, is a recent San Francisco arrival from Chicago.

Frank Fowden, manager of Brooks-Follis Company, left this week for Eureka, on pleasure bent.

W. E. Osburn, who is in the electrical business at Woodland, was a San Francisco visitor last week.

A. D. Bowen, who was at one time general manager of the Ocean Shore Railway, is a San Francisco visitor.

W. S. Heger, Pacific Coast manager for the Allis-Chalmers Company, is spending a few days in Southern California.

Thomas Mirk, of Hunt, Mirk & Co., has gone to San Diego, where his firm is erecting an electric power plant.

Leon Bly of Red Bluff, who has electric power and irrigation interests in Northern California, was a recent San Francisco visitor.

Sidney Sprout, electrical engineer, has gone to Los Angeles on engineering business and will return to San Francisco next week.

A. S. Kalenborn, electrical engineer for the Reno Power, Light and Water Company of Reno, Nevada, visited San Francisco this week.

Delos A. Chappelle, who is interested in hydro-electric developments, has returned to Mono County after visiting his San Francisco office.

E. M. Frazer, an inventor and manufacturer of electric elevators, has arrived from the East and may spend some time at San Francisco.

F. E. Vickers, assistant engineer of the General Electric Company's San Francisco office, has returned from a trip to New York and other Eastern cities.

E. G. Dewald, in charge of the water wheel department of the Allis-Chalmers Company on the Pacific Coast, is again at the company's San Francisco office after a trip to the factory at Milwaukee, Wis.

W. G. B. Euler has taken charge of the Big Bend plant of the Great Western Power Company. Mr. Euler has been with the General Electric Company for a number of years as an engineer of construction.

E. G. Williams, who has general charge of J. G. White & Co.'s engineering business, has just arrived at the San Francisco office. J. W. Burke, engineer with the same corporation, arrived last week from Denver.

H. G. Boardman is chief engineer for large electric power and gold-dredging interests in Alaska. He a rived at San Francisco for the purpose of purchasing machinery and supplies. He has his headquarters at Dawson, Yukon Territory.

Charles P. Morrill, formerly Santa Rosa Manager for the Pacific Telephone and Telegraph Company, has been promoted to the position of assistant to the general superintendent at the San Francisco offices. A. F. Lafranchi, manager of the Petaluma exchange, has taken Mr. Morrill's place at Santa Rosa.

Kamakichi Takata, of Takata & Co., the Japanese agents of the Westinghouse Electric and Manufacturing Company, spent a few days last week inspecting the factories and power plants of San Francisco. S. Furmi, of Takata & Co.'s New York office, came West to meet the head of the firm and left with Mr. Takata for the East May 23.

Among the San Francisco engineers who went to Los Angeles during the past week to attend the seventh annual convention of the California State Association of the National Association of Stationary Engineers were: H. N. Saville, William Millner, Herman Nothig, William Jenkins, Charles Knight, Frank Carmody and Charles Dick.

MEETING OF NORTHWEST ELECTRIC LIGHT AND POWER ASSOCIATION.

The annual convention of the Northwest Electric Light and Power Association will be held this year on the steamer Queen leaving Seattle the evening of August 26th and returning the morning of August 29th. The boat has been chartered for the trip and will visit the various Sound cities with stop-overs at each place. The cost of the entire trip including berth and meals will be but $10 a person. This gives an excellent opportunity for the delegates to get acquainted with each other and discuss the business and operative problems that confront them. An orchestra will be taken on the trip and everything possible done for the entertainment of the members. Part of the freight deck has been assigned to the various supply companies who are members of the Association, where they will be permitted to install such exhibits as they choose. The program as outlined includes papers on "Long Distance Transmission," "Depreciation," "The Rate Question," "Employers' Liability," "Methods of Getting Business" and "Conservation," all by speakers of ability. It is expected, however, that the greatest good will be accomplished by the opportunity the three days' trip will give for discussion.

NEW CATALOGUES.

"Attitude of Central Stations Toward Electric Automobiles" is the subject of Bulletin No. 123 from the Electric Storage Battery Company. In it is told the profitable results obtained by the electric lighting company at Rochester, N. Y.

Bulletin 7B from the Engineering Department of the National Electric Lamp Association presents valuable data on illumination, so arranged and condensed that the correct illumination of any place may be quickly calculated. In addition to excellent tables and formulas this bulletin shows typical lamps and reflectors for various uses.

"High Vacuum Surface Condensers for Steam Turbines" is the title of Bulletin 106, published by the Wheeler Condenser and Engineering Company of Carteret, N. J. The high steam economy obtainer by steam turbines with vacuums of 28 to 29 inches is pointed out, while on the other hand it is shown that in obtaining these high vacuums there should be no unnecessary power consumption by the condenser auxiliaries, or excessive amounts of water used for cooling purposes. This pamphlet describes arrangements of the tube surface, the use of rain plates and other means recently devised for obtaining these results.

TRADE NOTE.

R. B. Guernsey has been appointed San Francisco representative of the C. H. Wheeler Manufacturing Company of Philadelphia, succeeding Frank R. Wheeler, who has been transferred to the Chicago office of the company as manager.

The Los Angeles Gas & Electric Corporation have purchased from the C. H. Wheeler Manufacturing Company two complete surface condensing units for two large compound gas compressors recently installed. Each unit includes the new Pratt rotrex vacuum pump.

The General Electric Company has closed a contract for an additional 12,000 kw. Curtis turbine generating unit, which is to be installed in the San Francisco Gas and Electric Company's Station "A," under the supervision of J. G. White & Co. The new vertical turbine has a condenser base and is rated as follows: A. T. B. 10, 12,000 kw., 720 r.p.m., 11,000 v.

BOOKS RECEIVED.

Dynamo Building for Amateurs. By A. J. Weed; 81 pages; 4½x7½; 64 illustrations. Norman W. Henley Publishing Company, New York, and Technical Book Shop, San Francisco. Price, cloth, $1.00; paper, 50 cents.

As implied by the title this is a manual of practical instruction on building a small dynamo or motor, the machine work of which can be done on a small foot lathe. In it are working dimensional drawings and detailed directions for making a 50-watt dynamo.

The Control of Use of Stream Waters in the United States. By Russell L. Dunn; 65-page pamphlet published by the author, Metropolis Bank Building, San Francisco; sold by Technical Book Shop, San Francisco. Price, 50 cents.

This dissertation deals with the subject of conservation of water power from the standpoint of the company that is formed to develop such power, but is hindered by governmental restrictions. Two points specially emphasized are the prevalent misunderstanding as to the definition of a water power site and the question of state ownership of water rights over which federal jurisdiction is now being extended. Included in it is a comprehensive summary of the laws relative to water appropriation and use in California. In its entirety it is an able exponent of the "other side" of what hitherto has been largely a one-sided argument.

Report on Foreign Labor Conditions. By Harris Weinstock; 157 pages; 5½x9. Published by State Printer, Sacramento, California.

In 1908 Governor Jas. M. Gillett appointed Mr. Harris Weinstock Special Labor Commissioner to examine into the labor conditions and labor laws of foreign countries and report his conclusions as to remedies for strikes and lockouts. In this volume is embodied the results of his investigations in Italy, Russia, Austria, Germany, Belgium, France, England, Australia and New Zealand. The statement of conditions in these countries is most interesting, as are also the author's conclusions. These embrace an indorsement of the principle of State intervention in labor disputes, including public inquiry in labor disputes before they reach the serious stage of a strike or lockout.

Municipal Franchises. By Delos F. Wilcox; 710 pages; 5x8. Enginering News Book Department, New York and Technical Book Shop, San Francisco. Price, $5.00.

Herein is given a description of the terms and conditions upon which private corporations enjoy special privileges in American cities. The work is divided into two volumes, this, the first, containing an introductory analysis of the modes of acquiring franchise rights, of the nature of franchises and the various possible means of restricting public utility monopolies under private operation. The several classes of municipal franchises are then discussed in detail, this volume dealing with wire and pipe franchises, the former including the telephone, telegraph, lighting heat and power and the latter water supply, sewers, central heating, refrigeration, pneumatic tubes, oil lines and gas. The second volume, to come within a year, will discuss transportation and terminal franchises together with observations on the taxation and control of public utilities. In each case a brief sketch is given of the history and importance of the utility, followed by examples of typical franchises in actual operation in different American cities. The author, who is Chief of the Bureau of Franchises of the Public Service Commission for the first district of New York, is a recognized authority on this and kindred subjects. He believes that "a public franchise is a public trust" and he indicates how private operation of public utilities may be best regulated. As a reference work it is valuable alike to the engineer and the lawyer, giving the most comprehensive summary of American franchise provisions yet published. It presents pertinent facts and deduces rational conclusions on a subject which is daily increasing in popular interest.

Auto-Transformer Design. By A. H. Avery; 60 pages; 5½x8½; 25 illustrations. Spon & Chamberlain, New York and Technical Book Shop, San Francisco. Price, $1.50.

Anyone who has ever tried to make a small transformer and found how little practical information is available will appreciate this book. The designers of large transformers for manufacturing companies have reduced their work to a science, but the individual who wishes to make his own apparatus has great difficulty in understanding and adapting their information to his needs. This want is admirably supplied in this volume for small transformers in general and auto-transformers in particular. The book contains six chapters. After defining and comparing the different types of transformers and discussing the advantages of transforming to low pressure for lighting, the author develops the elementary theory and presents the fundamental formulae necessary, this including a clear explanation of iron and copper calculations. In the chapter on practical design a typical problem is worked out, detailing every step in the calculation. This is supplemented by a simple explanation of how the efficiency of the transformer may be determined. The final chapter gives practical constructional details, including core assembling, coil winding, insulating, mounting and enclosing, well illustrated by line cuts and half tones. The text substitutes for the rule of thumb methods hitherto used rational explanations and practical directions which should enable anyone not only to make an auto-transformer, but also understand its theory.

American Producer Gas Practice. By Nisbet Latta; 539 pages; 7½x10½; 247 illustrations. D. Van Nostrand Company, New York and Technical Book Shop, San Francisco. Price, $6.00.

Nisbet Lotta is one of the foremost American authorities on gas engines and gas producers. In this volume he has ably delineated typical practice couched in such language that even the layman may understand. It is a welcome relief upon turning to the first page to find that the author omits all history, ancient and otherwise, and proceeds at once with the practical features of producer design and operation. The book consists of twenty-two chapters and an appendix. These are concerned respectively with producer operation, cleaning the gas, works details, producer types, moving gases, solid fuels, physical and chemical properties of gases, gas analysis, gas power, gas engines, industrial gas applications, furnaces and kilns, burning lime and cement, pre-heating air, combustion, properties and measurement of heat, data on pipes, flues and chimneys, useful tables and oil fuel producer gas. The treatment of each individual subject is as comprehensive as is the handling of the entire field as above outlined. Written description is well-supplemented by reproductions from photographs and drawings. With so much to commend it is unfortunate that the text should be marred by a number of typographical errors, which should be corrected in future editions to which the book is undoubtedly destined. For instance, in the appendix on oil fuel producer gas, which is particularly interesting to Pacific Coast engineers in that it describes the Jones oil gas set, the Nix-Frost producer and the Amet Ensign producer, we find Professor Durand's name spelled "Durant," and Bakersfield given as "Bakersville." Doubt is at once created regarding the correctness of the names of individuals and places in other localities with which we may not be familiar. Except for these minor defects, this work should prove of value to everyone operating or contemplating the operation of a producer gas plant.

"California for the Settler" is the title of a handsomely illustrated book of 100 pages issued for free distribution by the advertising department of the Southern Pacific Company. In it are detailed the advantages of rural life in this State.

INDUSTRIAL

A NEW FORM OF HEAD FOR BOILER TUBE CLEANERS.

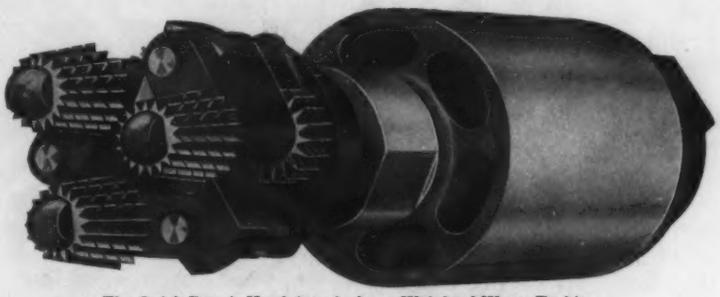
The Lagonda Manufacturing Company, of Springfield, Ohio, have recently put out a new boiler tube cleaner equipped with what is known as the "Quick Repair Head." This head is the result of several years of experimenting, and is said to be the simplest and most compact head for use on turbine tube cleaners that has yet been brought out. The head is attached to the cleaner turbine proper by means of the coupling and an adapter. As can be seen from the accompanying drawing, a spider screws directly into the coupling, and has three arms on the end of which are attached the swinging arms carrying the cutter wheels. There are four cutters on each swinging arm; the front one being of the cone pattern, is the first to attack the scale and loosen it. Each cone cutter is then followed by three star cutters which remove the scale down to the metal, leaving a bright, polished surface.

The most important feature of this head is the ease with which new cutters can be inserted. The cutter pin can quickly be removed by means of a wrench and all of the cutter wheels taken out. In case it is necessary to take the entire head apart it is only necessary to unscrew the spider from the coupling; this allows the three arm pins to drop out and the whole head is dismantled. There are no rivets or small parts used and the makers furnish an extra supply of sharp cutter wheels with each head. As mentioned before, it is but the work of a minute to remove one of the pins and insert new sharp cutters. Keeping the head equipped with sharp cutters results in a marked saving in the time necessary to remove a given amount of scale from boiler tubes.

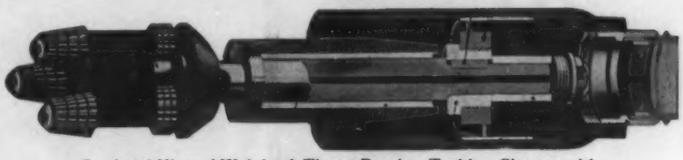
The quick repair head is compact and heavily built. The arms are thrown out against the scale by the action of centrifugal force. This causes the cutter wheels to bear firmly against the scale, but should a constricted part of the tube be met the arms fold in and do not injure the boiler tube in the least. The fly-wheel effect of a compact head like this is quite noticeable. When exceptionally hard scale is encountered it is only necessary to back the cleaner out a little, and let the head speed up and when it is forced against the scale again, it is generally found that the cleaner will eat its way through without any further trouble.

Those who are not familiar with the turbine construction may get a good idea of this from the cut of the Weinland thrust-bearing cleaner with quick repair head.

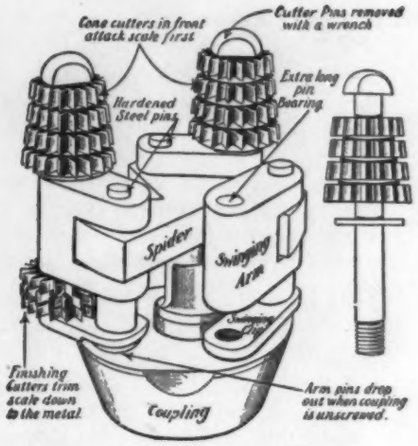
Charles C. Moore & Co., engineers are General Pacific Coast Agents for same.



The Quick Repair Head Attached to a Weinland Water Turbine.



Sectional View of Weinland Thrust-Bearing Turbine Cleaner with a Quick Repair Head Attached.


Cone cutters in front attack scale first
Cutter Pins removed with a wrench
Extra long pin Bearing
Hardened Steel pins
Spider
Swinging Arm
Finishing Cutters trim scale down to the metal
Coupling
Arm pins drop out when coupling is unscrewed.

The Quick Repair Head with One of the Cutter Pins Removed

TRADE NOTES.

The Board of Public Works of Los Angeles, Cal., has recently placed an order with Allis-Chalmers Company for twenty-one 440-volt, 3-phase, 60-cycle, belted induction motors for use in connection with the work on the new water supply aqueduct. Seven of these are 125 h.p. and the rest range down to 10 hp.

The Electric Storage Battery Company announces that it has opened two new sales offices, one at No. 729 Ford Building, Detroit, Mich., and another at 1424 Wazee street, Denver, Colo. The increasing use of the "Chloride Accumulator" and "Tudor Accumulator" for central stations, telephones, railways, and an enormous increase in the use of the "Exide" battery for electric vehicles, gas engine ignition, etc., has made it advisable to establish these offices, so that customers in adjacent territory will be better served. A stock of battery material will be carried in Denver from which orders can be promptly filled. The addition of these offices as well as the St. Louis "Exide" storeroom recently opened at Sixteenth and Pine streets materially increases the facilities of this company in the West.

It has been announced that the 12,000-kw. generating unit, which is to be installed in the Southern California Edison Company's new power station at Long Beach, is to be furnished by the General Electric Company. The contract calls for the following: One A. T. B. 12,000-kw., 750-r.p.m., 11,000-v., 3-phase, 50-cycle Curtis steam turbo-generator with condenser base. This turbine will have a continuous output of 15,000 k.v.a. at 80 per cent power factor, operating at 200 pounds steam pressure with 1½ pounds back pressure. The superheater will supply steam at 125 degrees. The contract include, also, two exciters, each consisting of a Curtis steam turbine driving a 4-pole, 125-kw., 125-v. shunt wound generator. The General Electric Company will supply for the above plant seven 2,000-kw., 50-cycle, forced oil, single-phase transformers. The voltages are 40,000 v. slant, 400 v. 70,000 v. with 11,000 v secondary.

NEWS NOTES

INCORPORATIONS.

MISSOULA, MONT.—The Clark-Missoula Power Company has been incorporated for $6,000,000 by W. A. Clark of Butte. The company is formed for promoting the new street railway here.

RIVERSIDE, CAL.—The Orange Heights Water Company has been incorporated by G. R. Murdock, F. E. Palmer, J. W. Long, J. H. Fairchild and E. H. Bagby, all of Los Angeles. The capital stock is $125,000.

SANTA FE, N. M.—The San Luis Power and Water Company, with a capital of $1,000,000, has been incorporated by F. E. Brooks, Gerald and Fred Hughes, F. C. Morflar, H. G. Lunt and H. A. Smith. The company's headquarters is at Colorado Springs, Colo., with W. F. Meyer as New Mexican agent. The company will operate in El Paso and Costilla Counties, Colo.

SAN MATEO, CAL.—The rumor that the San Mateo Water Company had taken over the holdings of the Burlingame Water Company was practically authenticated when the Peninsula Water Company filed articles of incorporation in Redwood City. The incorporators of the new company are the same as of the San Mateo Water Company—Joseph Levy, William F. Turbull, H. N. Royden, J. A. Foster and Charles N. Kirkbride. The capital of the new corporation is $1,000,000.

TRANSMISSION.

THOMPSON, MONT.—Senator Dolan of Missoula and others contemplate the erection of a large power plant here.

SHERIDAN, MONT.—O. B. Preston, president of the Municipal lighting plant of St. Johns, Mich., will establish a power plant here and supply the city with light.

NORTH YAKIMA, WASH.—A deed has been filed for record transferring all the property of the Northwestern Corporation in this section to the Yakima-Pasco Power Company.

PORT ALBERNI, B. C.—A. E. Waterhouse, of Seattle, has applied for a record on the Sproat River of 500 inches, with the intention of erecting an electric power plant to supply Port Alberni.

VICTORIA, B. C.—Bids will be received up to June 6th by the Minister of Public Works for the construction of a transmission line for the purpose of furnishing electricity for the hospital for the insane at Coquitlam.

GRANGEVILLE, IDA.—A. W. Trine announces that Eastern capital has become interested in the Snake River power project near the mouth of the Salmon River and that development work will be started soon.

COEUR D'ALENE, IDA.—The Coeur d'Alene Indian Reservation Settlers' Association, Wm. Masi, Jr., of Spokane, president, is preparing to install electric power and telephone lines, establish schools, etc., on the reserve.

SAN BERNARDINO, CAL.—The Arrowhead Reservoir and Power Company has filed trust deeds to the amount of $2,000,000 to raise money for constructing additional tunnels and building outlets for power and irrigation purposes.

TACOMA, WASH.—The City Commissioners are considering plans for the purchase of water rights on the White River, ten miles above Buckley, owned by P. H. Hebb and offered to the city for $900,000. The proposed power plant will develop 100,000 hp. at a cost of $2,000,000.

ORLEANS, CAL.—The company that has taken up the water power at Ishi Pishi Falls has had favorable reports sent in by the Government officers and expects before long to receive its permit, when active operations will begin. This means and expenditure of over $1,000,000 in Humboldt County, the permanent employment of hundreds of men and the building of factories, probably near Trinidad. The company will divert the water from the river above the falls into a flume 16 feet wide and 12 feet deep, tunnel through Sugar Loaf mountain and carry water to the next falls, a distance of a mile, where the pressure will give them 50,000 hp. all the year. The rock tunnel will also be 12x16 feet and will be 1500 feet long.

TRANSPORTATION.

SPOKANE.—The Okanogan Electric Company has applied for a franchise for a track on Nettleton street.

BOZEMAN, MONT.—The Gallatin Valley Electric Railway has completed plans for the erection of a depot in this city.

MARSHFIELD, ORE.—The Council has granted the Coos Bay Rapid Transit Company a franchise for building an electric line in Marshfield.

EUGENE, ORE.—The City Council has granted a franchise providing for the College Hill loop, which will add about six miles to the present street car system.

BAKERSFIELD, CAL.—A new franchise has been granted the Power, Transit and Light Company for an extension of its lines so that cars may be run to the fair grounds.

STOCKTON, CAL.—The Central California Traction Company has applied for a fifty-year franchise for an electric line on the streets and highways of San Joaquin County.

NEW WESTMINSTER, B. C.—It is announced that bids are to be asked soon for the construction of the proposed $80,000 depot of the British Columbia Electric Railway here.

SAN DIEGO, CAL.—The City Council has passed an ordinance granting to the San Diego Electric Company a street railway franchise along and up K street, Twenty-second and other streets.

HOOD RIVER, ORE.—The Hood River Electric Light, Power and Water Company has been sold to the Hood River Power and Water Company. One of the projects of the company is the construction of an electric railway.

LEWISTON, MONT.—E. H. Begeman, a capitalist from Holland, has announced his intention of building an electric road between this place and Holland, and residents of this place have agreed to subscribe $100,000 toward the project.

RAYMOND, WASH.—P. E. Hall, Jr., owner of the South Bend electirc lighting system, has applied for a franchise for a term of forty-five years, to construct and operate an electric street railway system in Raymond.

SEATTLE.—C. H. Shields of the Spokane Grain and Fuel Company, and others propose to construct an electric railway to Green Lake via Fourth avenue and a tunnel under Queen Anne hill to Evanston avenue, crossing the canal at Etruria street.

LOS ANGELES, CAL.—The line of the Los Angeles Railway which now extends to the intersection of Thirty-ninth street and Vermont avenue will be extended to Western from Vermont avenue. The track will be double and more than a mile in length.